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15. ANIMAL BIOCHEMISTRY

Unit 1: Scope of Biochemistry in animal sciences

Physical properties of water-the medium of life, Acids and bases, ionic strength and activity, Henderson-Hasselbach equation, pH, indicators and buffers, Colloids and their properties, Structure and functions of bio- membranes with special reference to active transport of ions and metabolites. Mechanism of osmosis, osmotic pressure, Donnan membrane equilibrium, Viscosity, surface tension, surface forces, Adsorption and light scattering, Membrane filtration, dialysis, diffusion coefficient and partial specific volume. Structural and functional organization of prokaryotic and eukaryotic cells. Compartmentalization of metabolic processes within the cell and fractionation of subcellular components.

Unit 2: Carbohydrates

Structure and properties of biologically important carbohydrates including storage and structural polysaccharides, mucopolysaccharides, blood group substances, peptidoglycans and bacterial polysaccharides. Structure and properties of fatty acids, acyl glycerol, glycerophospholipids, sphingolipids, glycolipids, sulfolipids, aminolipids, sterols, bile acids and prostaglandins. Basic principle s of isolation, estimation and analysis of carbohydrates and lipids.

Unit 3: Amino Acids

Amino acids, structure and properties. Primary, secondary, tertiary and quaternary structure of proteins. Glycoproteins, lipoproteins, nucleoproteins, fibrous and globular proteins. Structure and functions of immunoglobulins, myoglobin and hemoglobin. Physical and chemical properties of proteins. Structure of different types of nucleic acids. Acid base properties, sedimentation behavior, hyperchromic effect, base sequencing and restriction analysis of DNA.

Unit 4: Enzymes

Major classes of enzymes, general properties, kinetics and mechanism of their action. Activation energy and transition state. Coenzymes and cofactors. Regulation of enzyme activity and enzyme inhibition. isoenzymes and enzymes of clinical significance. Applications and scope of enzymes in bioprocess technology and genetic engineering.

Unit 5: Bioenergetics

Bioenergetics, biological oxidation, respiratory chain and oxidative phosphorylation. Citric acid cycle and ATP generation. Glycolysis, pentose phosphate pathway and glycogenesis. Biosynthesis and oxidation of fatty acids. Volatile fatty acids as source of energy in ruminants. Ketogenesis and cause of ketosis in ruminants. Biosynthesis of sterols and phospholipids. Catabolism of amino acids, transamination and deamination, urea cycle. integration of carbohydrate, lipid and amino acid metabolism. Conversion of amino acids into other bioactive compounds. Biosynthesis of nutritionally non-essential amino acids. Metabolism of purines and pyrimidines. Disorders of lipid, carbohydrate, nucleic acid and amino acid metabolism. Inborn errors of metabolism and scope of gene therapy in combating genetic disorders.

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Unit 6:Transcription and traslation

Mechanism of storage, transmissions and expression of genetic information. DNA replication and control of gene expression in prokaryotes and eukaryotes. RNA synthesis and factors regulating transcription. Biosynthesis of proteins. Features of genetic code in prokaryotes and eukaryotes. Wobble hypothesis, post -translational modification, degeneracy and regulation of translation. Basic principles of recombinant DNA technology and its scope in animal health and production. Recombinant proteins and vaccines. safety, ethical issues and IPRs in molecular biology.

Unit 7: Vitamins

Structure and metabolic functions of water soluble and lipid soluble vitamins. Trace elements and their role in biological processes. Deficiencies and nutritional significance of vitamins and trace elements in domestic animals and poultry, *nutraceuticals* & probiotics. General description of nature of hormones, receptors and mechanisms of their action. Metabolic function of different hormones and associated disorders due to hypo or hyper secretions of major endocrine glands viz. pituitary, thyroid, parathyroid, adrenal, pancreas, pineal and gonads.

Unit 8: Biochemistry of blood

Blood composition and biochemical constituents of erythrocytes, leucocytes and platelets. Important plasma proteins and their functions. Hemoglobin in oxygen and carbon dioxide transport. Role of kidneys in acid base balance. Composition and metabolism of muscle,

connective, tissue, cartilage, bone, nervous, tissue, adipose tissue and mammary tissue. Clinical significance of iron, iodine, calcium and phosphorus metabolism in domestic animals and poultry. Biochemical t ests for hepatic and renal functions. Urine composition and analysis.
Biochemistry of Wild Animals - Blood biochemistry and blood typing of wild animals - Fluid balance and electrolyte maintenance in wild animals - Biomarkers for assessment of diseases in wild animals - Diabetes mellitus in primates - Neurological diseases in cheetah. Metabolism of xenobiotics and role of liver and kidneys in detoxification of xenobiotics

Unit 9: Determination of biochemical constituents

Basic principles and use of latest photometric, chromatographic. electrophoretic and radioisotopic methods of biochemical analysis. Methods of isolation, purification and characterization of proteins, DNA and RNA. Basic principles of RIA, ELISA, PCR, RFLP and DNA fingerprinting, NA probes, vectors, microarray, imaging, applications of nanotechnology, proteomics. Determination of enzymes, hormone, vitamins and other biochemical constituents with special reference to disease diagnosis in domestic animals.

Unit 10: Bioinformatics

Introduction to bioinformatics, scope and applications of bioinformatics; biological databases: primary, secondary and structural; basic concept of Protein and Gene Information Resources-PIR, SWISS-PROT, PDB, GenBank, DDBJ; Basic concept of computational biology, applications in different subfield of biology, software tools.
Basic concept of sequence search algorithm and alignment tools: BLAST and FASTA; DNA and protein sequence analysis, local and global alignment; Algorithms: Dot Matrix method, dynamic programming methods; Pairwise and multiple sequence alignment and its application; Tools of Multiple sequence alignment: ClustalW. Basic concept of Phylogeny study; cDNA libraries and EST, EST analysis; database search engines: introduction and application; Commercial databases and software packages, GPL software for Bioinformatics.Computer aided drug design: basic principles, docking; QSAR, 2DQSAR, 3DQSAR, their basic concept and applications, machine learning tools for QSAR.

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CHAPTER 01
Scope of Biochemistry in Animal Sciences

2001

1. Which discipline primarily studies the chemical processes within and related to living organisms?
(A) Biophysics
(B) Molecular biology
(C) Physical chemistry
(D) Biochemistry

2015

2. The geometry of a water molecule is best described as which of the following?
(A) Linear
(B) Tetrahedral
(C) Bent
(D) Trigonal planar

2008

3. Identify the incorrect statement regarding the Brønsted-Lowry concept of acids and bases.
(A) An acid is a proton donor.
(B) It applies only to aqueous solutions.
(C) A base is a proton acceptor.
(D) Conjugate acid-base pairs differ by a single proton.

2014

4. Match the items in List I with those in List II:
List I: Physiological buffers
P. Bicarbonate buffer
Q. Phosphate buffer
R. Protein buffer
S. Hemoglobin buffer
List II: Primary location
1. Intracellular fluid
2. Blood plasma
3. Intracellular fluid and plasma
4. Red blood cells
(A) P-1, Q-2, R-4, S-3
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-1, R-3, S-4

2004

5. The pH of a solution is mathematically defined as which of the following?
(A) Negative logarithm of hydrogen ion activity
(B) Natural logarithm of hydrogen ion concentration
(C) Inverse of the hydroxyl ion concentration
(D) Product of both ionic concentrations

2013

6. Which equation is used to calculate the pH of a buffer solution?
(A) Nernst equation
(B) Michaelis-Menten equation
(C) Henderson-Hasselbalch equation
(D) Gibbs-Helmholtz equation

2003

7. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The bicarbonate buffer system is the most important extracellular buffer.
Reason (R): The lungs and kidneys can regulate its components to maintain pH.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

8. In colloidal systems, the random zigzag motion of particles is termed as what?
(A) Tyndall effect
(B) Electrophoresis
(C) Zeta potential
(D) Brownian motion

2023

9. Select the incorrect pair regarding cell membrane components.
(A) Phospholipids - Amphipathic nature
(B) Sphingolipids - Absent in neural tissues
(C) Cholesterol - Membrane fluidity regulation
(D) Integral proteins - Transmembrane transport

2005

10. The Na^+/K^+ ATPase pump transports ions across the plasma membrane in which ratio?
(A) 2 Na^+ out and 3 K^+ in

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(B) 3 Na^+ in and 2 K^+ out
(C) 3 Na^+ out and 2 K^+ in
(D) 2 Na^+ in and 3 K^+ out

2010

11. What is the correct sequence of organelle involvement in the secretory pathway?
(A) Nucleus, Smooth ER, Golgi apparatus, Plasma membrane
(B) Smooth ER, Lysosomes, Secretory vesicles, Plasma membrane
(C) Golgi apparatus, Rough ER, Plasma membrane, Secretory vesicles
(D) Rough ER, Golgi apparatus, Secretory vesicles, Plasma membrane

2002

12. Which physical law states that osmotic pressure is proportional to solute concentration and temperature?
(A) van 't Hoff equation
(B) Fick's law
(C) Raoult's law
(D) Henry's law

2012

13. The unequal distribution of diffusible ions across a membrane due to non-diffusible macromolecules is known as what?
(A) Active transport
(B) Gibbs-Donnan equilibrium
(C) Facilitated diffusion
(D) Osmosis

2017

14. Which of the following is an INCORRECT statement about blood viscosity?
(A) It depends on hematocrit.
(B) It is entirely determined by plasma proteins.
(C) It influences peripheral resistance.
(D) It is higher than the viscosity of water.

2012

15. The Langmuir isotherm is based on which fundamental assumption?
(A) Monolayer coverage on homogeneous sites
(B) Multilayer adsorption on heterogeneous sites
(C) Liquid condensation within capillary pores
(D) Interaction between the adsorbed molecules

2011

16. Consider the following statements regarding Fick's first law of diffusion:
I. Flux is proportional to the concentration gradient.
II. Diffusion coefficient is independent of temperature.
III. It applies to steady-state diffusion.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2014

17. Which separation technique relies on the differential diffusion rates of solutes through a semipermeable membrane?
(A) Ultracentrifugation
(B) Electrophoresis
(C) Chromatography
(D) Dialysis

2024

18. Match the items in List I with those in List II:
List I: Marker enzymes
P. Acid phosphatase
Q. Succinate dehydrogenase
R. Glucose-6-phosphatase
S. Catalase
List II: Organelles
1. Mitochondria
2. Lysosomes
3. Peroxisomes
4. Endoplasmic reticulum
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2

2015

19. Eukaryotic cells differ from prokaryotic cells by possessing which feature?
(A) Ribosomes
(B) Membrane-bound nucleus
(C) Plasma membrane
(D) Cytosol

2018

20. Arrange the following components in order of decreasing sedimentation coefficient (Svedberg units):
I. Whole eukaryotic cell
II. Nucleus
III. Mitochondrion
IV. Ribosome
(A) I, II, III, IV
(B) I, III, II, IV
(C) II, I, III, IV
(D) IV, III, II, I

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2005

21. Which organelle is primarily responsible for the degradation of long-chain fatty acids?
(A) Peroxisome
(B) Lysosome
(C) Golgi apparatus
(D) Smooth endoplasmic reticulum

2006

22. In subcellular fractionation, which technique separates particles based solely on their buoyant density?
(A) Differential centrifugation
(B) Rate-zonal centrifugation
(C) Isopycnic ultracentrifugation
(D) Gel filtration

2004

23. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The dielectric constant of water is very high.
Reason (R): Water molecules possess a strong dipole moment.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

24. A Lewis acid is defined as a substance that functions in what capacity?
(A) Proton donor
(B) Proton acceptor
(C) Electron pair donor
(D) Electron pair acceptor

2011

25. Which parameter represents the effective concentration of an ion in solution?
(A) Molarity
(B) Activity
(C) Molality
(D) Ionic strength

2010

26. What causes the Tyndall effect in a colloidal dispersion?
(A) Absorption of light by particles
(B) Refraction of light at phase boundaries
(C) Scattering of light by particles
(D) Emission of light by fluorophores

2006

27. Identify the incorrect statement concerning membrane transport.
(A) Simple diffusion occurs through the bilayer without requiring ATP.
(B) Facilitated diffusion is a protein-mediated passive process.
(C) Primary active transport involves the direct utilization of ATP.
(D) Secondary active transport is independent of ion gradients.

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2001

28. Consider the following statements regarding animal cell membranes:
I. Carbohydrates are found on the intracellular surface.
II. Cholesterol increases membrane fluidity at low temperatures.
III. Peripheral proteins are loosely attached to the surface.
IV. Phosphatidylserine is mainly on the inner leaflet.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) I and IV
(D) II and III

2014

29. Which mathematical relationship calculates the ionic strength of a solution?
(A) $I = \frac{1}{2}\sum c_i z_i$
(B) $I = \frac{1}{2}\sum c_i z_i^2$
(C) $I = \sum c_i z_i^2$
(D) $I = \frac{1}{2}\sum c_i^2 z_i$

2015

30. Which term describes a solution having the same osmotic pressure as intracellular fluid?
(A) Hypertonic
(B) Isotonic
(C) Hypotonic
(D) Atonic

2011

31. What drives the separation of molecules in ultrafiltration?
(A) Electrical potential gradient
(B) Hydrostatic pressure gradient

(C) Concentration gradient
(D) Temperature gradient

2004

32. Which component primarily reduces the surface tension in the alveoli of lungs?
(A) Surfactant
(B) Mucin
(C) Plasma proteins
(D) Hyaluronic acid

2023

33. Match the items in List I with those in List II:
List I: Biophysical property
P. High specific heat of water
Q. High latent heat of vaporization
R. High dielectric constant
S. Hydrogen bonding
List II: Physiological significance
1. Efficient cooling through sweating
2. Dissolution of ionic compounds
3. Temperature buffering in organisms
4. Cohesion and surface tension
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-3, R-2, S-1

2006

34. What is the fundamental basis for the choice of an acid-base indicator?
(A) Indicator pK_a matches pH at the equivalence point.
(B) Indicator pK_a is far from the equivalence point.
(C) Indicator is a strong acid or a strong base.
(D) Indicator changes color at pH 7.0 exactly.

2006

35. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Glycolysis occurs entirely in the cytosol of a eukaryotic cell.
Reason (R): The enzymes required for glycolysis are absent in the mitochondria.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

36. Which parameter best determines the rate of sedimentation of a spherical particle in an ultracentrifuge?
(A) The physical radius of the particle
(B) Inverse of the particle's total mass
(C) Square of the radius of the particle
(D) The color of the specific suspension

2002

37. Which technique is most appropriate for breaking tough tissue such as muscle for subcellular fractionation?
(A) Osmotic shock
(B) Mild detergent lysis
(C) Mechanical homogenization (e.g., Potter-Elvehjem)
(D) Freeze-thawing

2008

38. Identify the correct statement regarding zeta potential.
(A) It represents the potential at the actual surface of the particle.
(B) A value of zero for the potential effectively prevents coagulation.
(C) It is entirely independent of the ionic strength of the medium.
(D) It is the potential at the slipping plane of a colloidal particle.

2007

39. Which of the following is an example of secondary active transport?
(A) Calcium pump in the sarcoplasmic reticulum
(B) Sodium-glucose symporter in the intestine
(C) Proton pump in the stomach
(D) Potassium leak channels

2001

40. Select the correct sequence of phases in the typical growth curve of a bacterial culture.
(A) Lag, Log, Stationary, Death
(B) Log, Lag, Stationary, Death
(C) Lag, Stationary, Log, Death
(D) Stationary, Lag, Log, Death

2023

41. The pK_a of an acid is defined as which of the following?
(A) The pH at which it is half-dissociated
(B) The pH at which it is entirely protonated
(C) The pH at which it is entirely deprotonated
(D) The negative logarithm of its pH

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2013

42. Which lipid type constitutes the backbone of sphingomyelin?
(A) Sphingosine
(B) Glycerol
(C) Cholesterol
(D) Isoprene

2019

43. What is the primary function of the nucleolus?
(A) ATP synthesis
(B) Lipid synthesis
(C) Protein degradation
(D) Ribosome biogenesis

2009

44. Consider the following statements regarding the Golgi apparatus:
I. It is involved in protein glycosylation.
II. It consists of cis, medial, and trans cisternae.
III. It is continuous with the nuclear envelope.
IV. It is the site of sorting secretory proteins.
V. It plays a role in lysosome formation.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and V
(C) II, III and V
(D) III, IV and V

2012

45. In the Henderson-Hasselbalch equation, when the concentration of the conjugate base equals the concentration of the weak acid, what is true?
(A) $pH = pK_a$
(B) $pH = pK_a + 1$
(C) $pH = pK_a - 1$
(D) $pH = 7.0$

2018

46. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Red blood cells swell and may burst when placed in a hypotonic solution.
Reason (R): Water moves from a region of lower solute concentration to higher solute concentration across the membrane.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

47. Which mathematical model predicts multilayer gas adsorption on solid surfaces?
(A) Langmuir isotherm
(B) Freundlich isotherm
(C) Scatchard plot
(D) BET isotherm

2023

48. What represents the partial specific volume of a macromolecule?
(A) Change in solution volume per unit mass of added solute
(B) The volume of water displaced by one gram of the solute
(C) The total volume of the solution divided by solute mass
(D) The volume occupied by the hydration shell

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2017

49. Match the items in List I with those in List II:
List I: Transport mechanism
P. Simple diffusion
Q. Facilitated diffusion
R. Primary active transport
S. Secondary active transport
List II: Characteristic
1. Requires specific carrier, no ATP, down gradient
2. Movement of non-polar molecules down gradient
3. Driven by ion gradient created by an ATPase
4. Direct hydrolysis of ATP moves ions against gradient
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-3, Q-4, R-1, S-2

2023

50. The Gibbs-Donnan effect typically leads to which phenomenon in animal cells?
(A) A significant decrease in the intracellular osmotic pressure.
(B) The rapid destruction of the cell's internal lipid bilayer.
(C) Unequal distribution of diffusible ions across the membrane.
(D) Complete electrical neutrality of all intracellular proteins.

2022

51. Which factor decreases the fluid nature of the cell membrane at physiological temperatures?
(A) Increased cholesterol content
(B) High proportion of unsaturated fatty acids

(C) Short hydrocarbon tails of phospholipids
(D) Increase in temperature

2008

52. Consider the following statements regarding the rate of dialysis:
I. Larger membrane surface area
II. Higher temperature
III. Increased thickness of the membrane
IV. Greater concentration gradient
V. Use of smaller pore sizes
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and V
(C) II, III and IV
(D) I, IV and V

2016

53. Which term refers to the aggregation of colloidal particles caused by the addition of electrolytes?
(A) Peptization
(B) Dialysis
(C) Adsorption
(D) Coagulation

2015

54. Which is the least relevant criterion for selecting a buffer for a biochemical reaction?
(A) Its density compared to water
(B) Its pK_a value relative to the desired pH
(C) Its interaction with metal ions in the assay
(D) Its absorbance spectrum in the UV-visible range

2021

55. A cell homogenate is subjected to differential centrifugation. Which fraction pellets first at low speeds (e.g., 600 x g)?
(A) Nuclei
(B) Microsomes
(C) Mitochondria
(D) Cytosolic proteins

2006

56. What is the fundamental cause of surface tension in liquids?
(A) Adhesion between liquid and solid surfaces
(B) Unbalanced cohesive forces on surface molecules
(C) Expansion of gases dissolved in the liquid
(D) Covalent bonding between surface molecules

2022

57. Which equation describes light scattering by particles much smaller than the wavelength of light?
(A) Rayleigh scattering
(B) Mie scattering
(C) Raman scattering
(D) Compton scattering

2005

58. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Proteins act as effective biological buffers.
Reason (R): Proteins contain amino acid residues with ionizable side chains.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

59. The rough endoplasmic reticulum is characterized by the attachment of which structures?
(A) Lysosomes
(B) Peroxisomes
(C) Ribosomes
(D) Golgi vesicles

2006

60. Arrange the following steps of differential centrifugation in the correct order for isolating microsomes:
I. Centrifuge at 100,000 x g for 60 min
II. Homogenize the tissue
III. Centrifuge at 600 x g for 10 min
IV. Centrifuge at 15,000 x g for 20 min
(A) II, III, IV, I
(B) II, IV, III, I
(C) III, II, IV, I
(D) I, II, III, IV

2012

61. What defines the dielectric constant of a solvent?
(A) Its capacity to reduce the electrostatic attraction between dissolved ions
(B) Its ability to conduct electricity
(C) Its resistance to flow
(D) Its specific heat capacity

2018

62. Which structural feature primarily accounts for the unique properties of water, such as high boiling point and cohesion?
(A) Extensive hydrogen bonding networks

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(B) Covalent double bonds
(C) Ionic interactions
(D) Van der Waals forces

2021

63. Identify the incorrect statement regarding the acid and its conjugate base.
(A) H_2CO_3 / HCO_3^-
(B) CH_3COOH / H_3O^+
(C) H_3PO_4 / $H_2PO_4^-$
(D) NH_4^+ / NH_3

2018

64. Match the items in List I with those in List II:
List I: Organelle
P. Cytosol
Q. Mitochondria
R. Smooth ER
S. Lysosome
List II: Primary metabolic pathway
1. Lipid synthesis
2. Glycolysis
3. Macromolecular degradation
4. Citric acid cycle
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-3, Q-1, R-4, S-2

2013

65. The term 'amphipathic' refers to molecules that possess which characteristics?
(A) Both hydrophilic and hydrophobic regions
(B) Only hydrophilic regions
(C) Only hydrophobic regions
(D) Neither hydrophilic nor hydrophobic regions

2004

66. Which cellular junction prevents the leakage of extracellular fluid across a layer of epithelial cells?
(A) Gap junctions
(B) Desmosomes
(C) Tight junctions
(D) Plasmodesmata

2007

67. Which of the following is an example of a physiological weak acid?
(A) Hydrochloric acid
(B) Acetic acid
(C) Sulfuric acid
(D) Nitric acid

2018

68. Consider the following statements regarding the Gibbs-Donnan equilibrium:
I. It requires a completely permeable membrane.
II. It involves non-diffusible ions like proteins.
III. At equilibrium, the product of diffusible ions is equal on both sides.
IV. It prevents the generation of a transmembrane potential.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and IV
(C) II and III
(D) III and IV

2021

69. Which factor most heavily influences the sedimentation rate of a macromolecule during ultracentrifugation?
(A) The concentration of the buffer
(B) The shape and size of the macromolecule
(C) The color of the solution
(D) The specific heat of the solvent

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2003

70. What is the effect of an increase in temperature on the viscosity of biological fluids like blood plasma?
(A) Viscosity decreases
(B) Viscosity increases
(C) Viscosity remains unchanged
(D) Viscosity initially increases then drops to zero

2006

71. According to Fick's laws, diffusion rate is inversely proportional to which parameter?
(A) Concentration gradient
(B) Surface area of the membrane
(C) Thickness of the membrane
(D) Temperature

2003

72. Which principle states that the structure of the lipid bilayer is dynamic, allowing lateral movement of proteins and lipids?
(A) Singer-Nicolson fluid mosaic model
(B) Davson-Danielli model
(C) Unit membrane model
(D) Chemiosmotic theory

2014

73. Which of the following organelles is NOT part of the endomembrane system?
(A) Endoplasmic reticulum

(B) Golgi apparatus
(C) Lysosomes
(D) Mitochondria

2008

74. Which of the following components is primarily utilized in density-gradient centrifugation to form a stable gradient?
(A) Sucrose or Ficoll
(B) Sodium chloride
(C) Ethanol
(D) Urea

2013

75. Which statement is an INCORRECT inference from Fick's first law of diffusion?
(A) Diffusion rate increases as the concentration gradient increases.
(B) Diffusion ceases when equilibrium is reached.
(C) Diffusion occurs from regions of lower to higher concentration.
(D) The flux is directly proportional to the cross-sectional area.

2013

76. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Dialysis is ineffective for removing large protein molecules from a sample.
Reason (R): The pores of the dialysis membrane are too small to allow proteins to pass through.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

77. Which equation relates the activity of an ion to its concentration and the activity coefficient?
(A) $a = \gamma \times c$
(B) $a = \gamma + c$
(C) $a = \frac{\gamma}{c}$
(D) $a = c - \gamma$

2010

78. In terms of adsorption, what does the Freundlich isotherm empirically describe?
(A) Ideal monolayer adsorption
(B) Adsorption on heterogeneous surfaces
(C) Ion exchange capacity
(D) Osmotic pressure differences

2017

79. Match the items in List I with those in List II:
List I: Term
P. Svedberg unit (S)
Q. Dialysis
R. Osmosis
S. Electrophoresis
List II: Definition
1. Movement of solvent through a semipermeable membrane
2. Movement of charged particles in an electric field
3. Separation based on diffusion through a membrane
4. Measure of sedimentation velocity
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-1, Q-2, R-4, S-3
(D) P-2, Q-1, R-3, S-4

2025

80. Which technique separates proteins primarily based on their isoelectric point using a *pH* gradient?
(A) SDS-PAGE
(B) Isoelectric focusing
(C) Ion exchange chromatography
(D) Affinity chromatography

2006

81. Which is the predominant intracellular cation responsible for maintaining cellular osmolarity?
(A) Sodium
(B) Calcium
(C) Potassium
(D) Magnesium

2015

82. Arrange the following steps in determining a protein's subcellular location:
I. Perform Western blot with marker antibodies
II. Homogenize the tissue
III. Fractionate by differential centrifugation
IV. Isolate fractions
(A) II, III, IV, I
(B) III, II, I, IV
(C) II, IV, III, I
(D) I, II, III, IV

2005

83. The buffer capacity of a solution is maximized under which condition?

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(A) pH is exactly equal to pK_a
(B) pH is 2 units above pK_a
(C) Concentration of weak acid is zero
(D) Concentration of conjugate base is zero

2003

84. Which physical phenomenon explains the ability of certain biological fluids, like synovial fluid, to act as lubricants due to their viscosity changing under shear stress?
(A) Non-Newtonian flow behavior
(B) Ideal solution behavior
(C) Rayleigh scattering
(D) Osmosis

2003

85. Identify the incorrect statement concerning water as a biological solvent.
(A) It can form a maximum of only two hydrogen bonds per molecule.
(B) It has a higher heat of vaporization than most common liquids.
(C) Its solid form is less dense than its liquid form.
(D) It is an excellent solvent for polar molecules.

2023

86. Which parameter must be determined to use the Henderson-Hasselbalch equation for calculating pH?
(A) The ionic strength of the solvent
(B) The surface tension of the solution
(C) The ratio of conjugate base to weak acid
(D) The latent heat of the buffer

2023

87. Consider the following statements concerning lysosomes:
I. They contain hydrolytic enzymes.
II. Their internal pH is highly basic.
III. They are involved in autophagy.
IV. Acid phosphatase is a marker enzyme for them.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

2009

88. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Small, uncharged molecules like O_2 and CO_2 cross the plasma membrane easily.
Reason (R): They are highly soluble in the hydrophobic core of the lipid bilayer.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

89. In a prokaryotic cell, oxidative phosphorylation typically occurs at which site?
(A) Mitochondria
(B) Plasma membrane
(C) Cytoplasm
(D) Nucleoid

2022

90. Which structural feature restricts the free rotation around the peptide bond in proteins, influencing biophysical properties?
(A) Hydrogen bonding
(B) Ionic interactions
(C) Partial double bond character
(D) Disulfide bridges

2023

91. Match the items in List I with those in List II:
List I: Centrifugation type
P. Differential centrifugation
Q. Rate-zonal centrifugation
R. Isopycnic centrifugation
S. Analytical ultracentrifugation
List II: Basis of separation
1. Size and mass differences over time
2. Buoyant density equivalence
3. Sequential pelleting at increasing speeds
4. Continuous monitoring of sedimentation boundaries
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-4, S-1
(D) P-4, Q-1, R-3, S-2

2009

92. Which of the following represents the correct definition of one Svedberg unit (1S)?
(A) $10^{\{-13\}}$ seconds
(B) $10^{\{-9\}}$ seconds
(C) $10^{\{-6\}}$ seconds
(D) $10^{\{-15\}}$ seconds

2025

93. A competitive inhibitor affects enzyme kinetics in what characteristic way?

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(A) Decreases $V_{\{}max_{\}}$, leaves K_m unchanged
(B) Decreases both $V_{\{}max_{\}}$ and K_m
(C) Increases K_m, leaves $V_{\{}max_{\}}$ unchanged
(D) Increases both $V_{\{}max_{\}}$ and K_m

2018

94. The specific heat of a substance is defined as the amount of heat required to raise the temperature of:
(A) One mole of substance by one degree Celsius
(B) One liter of substance by ten degrees Celsius
(C) One gram of substance by one degree Celsius
(D) One kilogram of substance to its boiling point

2012

95. What structural component makes sphingolipids distinct from phosphoglycerides?
(A) Presence of a phosphate group
(B) Use of sphingosine instead of glycerol
(C) Presence of three fatty acid chains
(D) Complete absence of nitrogen

2012

96. Consider the following statements regarding active transport:
I. It moves solutes against their concentration gradient.
II. It relies on the kinetic energy of molecules alone.
III. It exhibits saturation kinetics.
IV. It is inhibited by metabolic poisons like cyanide.
V. It always involves symport mechanisms.
Which of the above statement(s) is/are correct?
(A) I, III and IV
(B) I, II and V
(C) II, III and V
(D) III, IV and V

2003

97. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Peripheral membrane proteins can be removed by washing the membrane with high salt solutions.
Reason (R): They are bound to the membrane surface primarily through electrostatic and hydrogen bonds.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

98. Which of the following is an example of an uncharged polar amino acid side chain at physiological pH?
(A) Serine
(B) Glutamate
(C) Lysine
(D) Leucine

2021

99. The asymmetrical distribution of lipids in the plasma membrane is maintained by which specific enzymes?
(A) Phospholipases
(B) Flippases and floppases
(C) Hydrolases
(D) Proteases

2013

100. In establishing a Gibbs-Donnan equilibrium, which condition must be met?
(A) There must be at least one impermeable charged species on one side.
(B) The membrane must be impermeable to all ions.
(C) Active transport must continuously operate.
(D) The temperature must remain at absolute zero.

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2005

101. Which term describes the phenomenon where a colloidal gel turns into a sol upon agitation and reverts to a gel upon resting?
(A) Syneresis
(B) Thixotropy
(C) Peptization
(D) Flocculation

2021

102. Which form of cellular homogenization utilizes high frequency sound waves?
(A) French press
(B) Sonication
(C) Dounce homogenization
(D) Bead beating

2021

103. Arrange the following molecules in order of increasing membrane permeability:
I. Water
II. Glucose
III. Sodium ion

IV. Oxygen gas
(A) III, II, I, IV
(B) II, III, I, IV
(C) IV, I, II, III
(D) I, IV, II, III

2001

104. Which of the following is NOT a property of eukaryotic mature red blood cells?
(A) Lack of a nucleus
(B) High concentration of mitochondria
(C) Biconcave shape
(D) Sole reliance on glycolysis for ATP

2013

105. Match the items in List I with those in List II:
List I: Biophysical technique
P. Ultrafiltration
Q. Dialysis
R. Light scattering
S. Ultracentrifugation
List II: Application
1. Desalting a protein solution
2. Concentrating macromolecules using pressure
3. Determining molecular weight based on sedimentation
4. Estimating molecular mass and radius of gyration
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2007

106. In animal health, the measurement of blood pH is critical. What is the normal physiological pH range of mammalian arterial blood?
(A) 7.35 - 7.45
(B) 7.15 - 7.25
(C) 7.55 - 7.65
(D) 6.80 - 7.00

2016

107. Which of the following processes requires a specific carrier protein but does not expend metabolic energy?
(A) Pinocytosis
(B) Simple diffusion
(C) Facilitated diffusion
(D) Primary active transport

2012

108. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The activity coefficient of an ion in a dilute solution approaches unity (1).
Reason (R): Interionic interactions become negligible at infinite dilution.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

109. Arrange the following in the correct sequence of the hierarchical organization of protein structure:
I. Amino acid sequence
II. Alpha helix
III. Polypeptide folding
IV. Multimeric assembly
(A) I, II, III, IV
(B) II, I, IV, III
(C) IV, III, II, I
(D) I, IV, III, II

2022

110. Which statement INCORRECTLY describes the behavior of strong electrolytes in solution?
(A) They dissociate completely into ions.
(B) They are excellent biological buffers at physiological pH.
(C) Their dissociation constant (Ka) is very high.
(D) They contribute significantly to the ionic strength of the fluid.

2014

111. The phenomenon of plasmolysis occurs when a cell is placed in which type of solution?
(A) Isotonic
(B) Hypotonic
(C) Hypertonic
(D) Atonic

2010

112. Consider the following statements regarding mitochondria:
I. They are the primary site of ATP generation.
II. They possess a single membrane.
III. They contain their own circular DNA.
IV. The inner membrane is highly folded into cristae.
V. They are part of the endomembrane system.
Which of the above statement(s) is/are correct?
(A) I, III and IV

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(B) I, II and V
(C) II, III and V
(D) III, IV and V

2001

113. What is the primary cause of a negative zeta potential on typical colloidal protein particles at pH 7.4?
(A) Predominance of deprotonated carboxyl groups.
(B) Predominance of positively charged side chains.
(C) Binding of sodium ions to the protein surface.
(D) Complete absence of any ionizable side groups.

2013

114. Which biophysical constant determines the amount of heat energy required to convert a liquid into a gas at constant temperature?
(A) Latent heat of vaporization
(B) Specific heat capacity
(C) Heat of fusion
(D) Dielectric constant

2014

115. A substance acts as a biological buffer most effectively when its pK_a is:
(A) Exactly 7.0, regardless of the target pH
(B) Within ± 1 pH unit of the desired physiological pH
(C) Extremely high, above 10
(D) Extremely low, below 3

2002

116. Match the items in List I with those in List II:
List I: Lipid component
P. Cardiolipin
Q. Glycolipids
R. Cholesterol
S. Phosphatidylinositol
List II: Cellular location or function
1. Outer leaflet of plasma membrane (cell recognition)
2. Inner mitochondrial membrane
3. Modulation of membrane fluidity
4. Cell signaling and membrane trafficking
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2014

117. Which mechanism accounts for glucose transport into erythrocytes?
(A) $GLUT_1$ mediated facilitated diffusion
(B) Simple diffusion
(C) Primary active transport
(D) Pinocytosis

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2014

118. Which statement is an INCORRECT inference from Fick's first law of diffusion?
(A) Diffusion rate increases as the concentration gradient increases.
(B) Diffusion ceases when equilibrium is reached.
(C) Diffusion occurs from regions of lower to higher concentration.
(D) The flux is directly proportional to the cross-sectional area.

2014

119. Consider the following statements regarding eukaryotic ribosomes:
I. They are composed of a 40S and a 60S subunit.
II. Their total sedimentation coefficient is 100S.
III. They are found free in the cytosol.
IV. They synthesize proteins for the endomembrane system when bound to the ER.
Which of the above statement(s) is/are correct?
(A) I and III
(B) II and IV
(C) II only
(D) III and IV

2019

120. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Plant cells do not burst when placed in distilled water.
Reason (R): Plant cells possess a rigid cell wall that exerts turgor pressure to counteract osmotic entry of water.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

121. What is the effect of an increase in ionic strength on the dissociation constant (pK_a) of a weak acid in solution?
(A) It can alter the apparent pK_a due to changes

in activity coefficients.
(B) It significantly increases the pK_a, making it a weaker acid.
(C) It has absolutely no effect under any circumstances.
(D) It immediately denatures the weak acid.

2006

122. Which process is specifically referred to as cell drinking?
(A) Pinocytosis
(B) Phagocytosis
(C) Receptor-mediated endocytosis
(D) Exocytosis

2001

123. The function of acid phosphatase as a marker enzyme is utilized to identify which subcellular fraction?
(A) Nuclei
(B) Mitochondria
(C) Lysosomes
(D) Cytosol

2019

124. Arrange the following steps for the derivation of the Henderson-Hasselbalch equation:
I. Take the negative logarithm of both sides.
II. Write the equilibrium constant (Ka) expression for a weak acid.
III. Solve the equation for $[H^+]$.
IV. Substitute pH for $-\log[H^+]$ and pK_a for $-\log(K_a)$.
(A) II, III, I, IV
(B) I, II, III, IV
(C) III, I, II, IV
(D) II, I, IV, III

2010

125. The Donnan equilibrium equation for a system with diffusible ions Na^+ and Cl^- and non-diffusible protein on side A is properly represented as:
(A) $[Na^+]_A \times [Cl^-]_A = [Na^+]_B \times [Cl^-]_B$
(B) $[Na^+]_A + [Cl^-]_A = [Na^+]_B + [Cl^-]_B$
(C) $\frac{[Na^+]_A}{[Cl^-]_A} = \frac{[Na^+]_B}{[Cl^-]_B}$
(D) $[Na^+]_A \times [Cl^-]_B = [Na^+]_B \times [Cl^-]_A$

2007

126. Which type of chromatography separates molecules based exclusively on their size and shape?
(A) Ion-exchange chromatography
(B) Gel filtration chromatography
(C) Affinity chromatography
(D) Hydrophobic interaction chromatography

2022

127. Which of the following organelles relies on proton pumps to maintain a highly acidic internal environment?
(A) Nucleus
(B) Endoplasmic reticulum
(C) Peroxisome
(D) Lysosome

2001

128. Identify the INCORRECT statement regarding the Na^+/K^+ ATPase pump.
(A) It maintains high intracellular sodium levels.
(B) It requires ATP hydrolysis.
(C) It is an electrogenic pump.
(D) It undergoes conformational changes during the cycle.

2001

129. Match the items in List I with those in List II:
List I: Surface chemistry term
P. Adsorption
Q. Absorption
R. Desorption
S. Chemisorption
List II: Context
1. Accumulation on a surface
2. Penetration into the bulk phase
3. Removal from a surface
4. Formation of chemical bonds at the surface
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2024

130. What is the cause of the hydrophobic effect in aqueous solutions?
(A) Strong attraction between nonpolar molecules
(B) Maximization of entropy of the water molecules
(C) Repulsion between water and nonpolar molecules
(D) Formation of covalent bonds between lipid tails

2019

131. In the context of biochemistry, the primary reason the lung operates effectively in buffering blood is because it can readily eliminate which volatile acid equivalent?
(A) Carbon dioxide

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(B) Lactic acid
(C) Acetoacetic acid
(D) Phosphoric acid

2004

132. Consider the following statements regarding peroxisomes:
I. They contain catalase.
II. They break down hydrogen peroxide.
III. They possess a double membrane.
IV. They participate in beta-oxidation of very long-chain fatty acids.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I, II and III

2015

133. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The inner mitochondrial membrane is highly impermeable to most ions and polar molecules.
Reason (R): This impermeability is essential to maintain the proton motive force for ATP synthesis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

134. Which phenomenon occurs when the solvent flows out of a colloidal sol, leading to shrinkage of the gel?
(A) Syneresis
(B) Imbibition
(C) Thixotropy
(D) Peptization

2003

135. The movement of water across a semipermeable membrane due to solute concentration differences is most accurately termed:
(A) Active transport
(B) Dialysis
(C) Ultrafiltration
(D) Osmosis

2025

136. Which structural parameter best describes the extent of non-ideality of an ion in solution?
(A) Activity coefficient
(B) Molarity
(C) Molality
(D) Osmotic coefficient

2021

137. Which statement represents a disadvantage of mechanical tissue homogenization compared to osmotic lysis?
(A) It is less effective on fibrous tissues like muscle.
(B) It can generate localized heat, potentially denaturing proteins.
(C) It cannot be scaled up for large volumes.
(D) It requires highly pure water to function.

2024

138. The smooth endoplasmic reticulum is abundant in cells specialized for the synthesis of which class of molecules?
(A) Glycoproteins
(B) Steroid hormones
(C) Nucleic acids
(D) Soluble cytosolic proteins

2022

139. Arrange the following biologically relevant interactions in order of increasing typical bond energy:
I. Van der Waals interactions
II. Hydrogen bonds
III. Covalent bonds
(A) I, II, III
(B) II, I, III
(C) III, II, I
(D) I, III, II

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2002

140. Which of the following equations accurately calculates the osmotic pressure (π) of a dilute non-electrolyte solution?
(A) $\pi = MRT$
(B) $\pi = \frac{M}{RT}$
(C) $\pi = \frac{RT}{M}$
(D) $\pi = M^2RT$

2025

141. Match the items in List I with those in List II:
List I: Subcellular organelle
P. Nucleus

Q. Mitochondria
R. Plasma membrane
S. Cytosol

List II: Common marker enzyme

1. DNA polymerase
2. Cytochrome c oxidase
3. Na^+/K^+ ATPase
4. Lactate dehydrogenase

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2009

142. Identify the INCORRECT statement regarding the fluid mosaic model.
(A) The membrane is a rigid, static structure.
(B) Lipids can diffuse laterally within the leaflet.
(C) Integral proteins span the lipid bilayer.
(D) Carbohydrates are attached to proteins and lipids on the extracellular surface.

2016

143. Which buffering system is predominantly responsible for maintaining the intracellular pH of erythrocytes?
(A) Hemoglobin buffer
(B) Bicarbonate buffer
(C) Phosphate buffer
(D) Acetate buffer

2016

144. In a normal mammalian cell, the concentration of potassium (K^+) is:
(A) Higher in the intracellular fluid than outside the cell
(B) Higher in the extracellular fluid than inside the cell
(C) Equal on both sides of the membrane
(D) Essentially zero inside the cell

2013

145. Consider the following statements concerning light scattering in macromolecular solutions:
I. It is caused by fluctuations in refractive index.
II. It can be used to determine the weight-average molecular weight.
III. The intensity of scattered light is inversely proportional to the fourth power of the wavelength.
IV. It only occurs in completely opaque solutions.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

2021

146. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Facilitated diffusion cannot transport a molecule against its concentration gradient.
Reason (R): Facilitated diffusion does not couple transport to the hydrolysis of ATP or any other energy source.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

147. Which of the following properties is least relevant to the physiological function of water?
(A) High dielectric constant
(B) High surface tension
(C) High latent heat of vaporization
(D) High flammability

2025

148. Which term refers to the volume of solvent that is inherently bound to a macromolecule in solution?
(A) Hydration volume
(B) Partial specific volume
(C) Excluded volume
(D) Void volume

2001

149. In Brønsted-Lowry acid-base theory, an acid-base reaction essentially involves the transfer of what entity?
(A) A proton
(B) An electron
(C) A pair of electrons
(D) A neutron

2008

150. Which organelle modifies, sorts, and packages proteins destined for secretion?
(A) Smooth endoplasmic reticulum
(B) Golgi apparatus
(C) Mitochondrion
(D) Nucleolus

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2007

151. Arrange the following pH values in order of increasing hydrogen ion concentration:
I. pH 2.0
II. pH 4.0
III. pH 7.0
IV. pH 9.0
(A) IV, III, II, I
(B) I, II, III, IV
(C) III, IV, II, I
(D) II, I, IV, III

2023

152. Match the items in List I with those in List II:
List I: Type of active transport
P. Uniport
Q. Symport
R. Antiport
List II: Definition
1. Two species move in opposite directions
2. One species moves in one direction
3. Two species move in the same direction
(A) P-2, Q-3, R-1
(B) P-1, Q-2, R-3
(C) P-3, Q-1, R-2
(D) P-2, Q-1, R-3

2002

153. A buffer is prepared using equimolar amounts of acetic acid and sodium acetate. The pK_a of acetic acid is 4.76. What is the pH of the buffer?
(A) 3.76
(B) 4.76
(C) 5.76
(D) 7.00

2017

154. Identify the INCORRECT statement regarding cell structures and their functions.
(A) Ribosome - Protein synthesis
(B) Nucleolus - Lipid synthesis
(C) Lysosome - Intracellular digestion
(D) Mitochondrion - Cellular respiration

2015

155. Which biophysical principle governs the migration of charged colloidal particles under the influence of an electric field?
(A) Electrophoresis
(B) Electro-osmosis
(C) Streaming potential
(D) Sedimentation potential

2015

156. Consider the following statements regarding the Gibbs-Donnan equilibrium's physiological impact:
I. It contributes to the generation of a resting membrane potential.
II. It requires energy from ATP to maintain the ion gradients.
III. It results in slightly higher osmotic pressure inside the cell due to trapped proteins.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2005

157. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The surface tension of water drops significantly when a surfactant is added.
Reason (R): Surfactants disrupt the extensive hydrogen bonding network at the air-water interface.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

158. Which physiological fluid demonstrates non-Newtonian, shear-thinning rheological behavior critical for joint lubrication?
(A) Synovial fluid
(B) Blood plasma
(C) Cerebrospinal fluid
(D) Gastric juice

NODIA

2022

159. The Tyndall effect is not observed in true solutions because:
(A) Solute particles are too large to scatter light.
(B) True solutions completely absorb visible light.
(C) Solute particles are smaller than the wavelength of visible light and do not scatter it significantly.
(D) True solutions lack a solvent phase.

2019

160. Which technique would most efficiently separate molecules of 10 kDa from molecules of 100 kDa without applying an electric field or centrifugal force?
(A) Gel filtration chromatography (Size exclusion)
(B) Differential centrifugation
(C) Ion exchange chromatography
(D) Isoelectric focusing

2023

161. In the context of subcellular fractionation, which statement best defines a "microsomal fraction"?
(A) Fragments of endoplasmic reticulum and plasma membrane.
(B) Mixture of intact mitochondria and digestive lysosomes.
(C) Exclusive collection of free ribosomes in the cytosol.
(D) Large, unbroken whole cells and their intact nuclei.

2002

162. Match the items in List I with those in List II:
List I: Constant or equation
P. Dielectric constant
Q. Henderson-Hasselbalch equation
R. van 't Hoff equation
S. Fick's first law
List II: Biological relevance
1. Buffer preparation and pH estimation
2. Dissolving capacity of water for ions
3. Calculation of osmotic pressure
4. Rate of passive diffusion
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2019

163. The addition of a small amount of strong acid to a bicarbonate buffer system primarily leads to an increase in the concentration of which molecule?
(A) Carbonate ion ($CO_3^{\{2-\}}$)
(B) Carbonic acid (H_2CO_3) / dissolved CO_2
(C) Bicarbonate ion (HCO_3^-)
(D) Hydroxyl ion (OH^-)

2018

164. What is the fundamental difference between simple diffusion and facilitated diffusion?
(A) Simple diffusion requires ATP.
(B) Facilitated diffusion exhibits saturation kinetics at high substrate concentrations.
(C) Facilitated diffusion moves substances against a gradient.
(D) Simple diffusion only applies to large proteins.

2018

165. Consider the following statements regarding standard tissue homogenization:
I. Mincing the tissue into small pieces.
II. Suspending in an isotonic buffer.
III. Subjecting to mechanical shear or acoustic disruption.
IV. Boiling the sample for 10 minutes to denature proteases.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) I, II and III
(D) II, III and IV

2001

166. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Eukaryotic cells exhibit spatial regulation of metabolic pathways by compartmentalization.
Reason (R): Organelles provide isolated environments with specific local conditions (e.g., pH, enzyme concentrations) optimized for particular reactions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

167. Which of the following best defines the 'zeta potential' of a colloidal particle?
(A) Potential difference between the medium and the stationary layer.
(B) The maximum velocity the particle can achieve during ultracentrifugation.
(C) The number of protons tightly bound to the particle surface.
(D) The total mass of the hydration shell.

2002

168. If the pH of a solution is 3, what is the concentration of H^+ ions in moles per liter?
(A) 1×10^{-3}
(B) 1×10^{3}

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(C) 3×10^{-1}
(D) 1×10^{-11}

2004

169. What is the primary function of the cholesterol molecules embedded within the animal cell membrane?
(A) To act as a primary energy source
(B) To modulate membrane fluidity and stabilize the lipid bilayer
(C) To form channels for ion transport
(D) To serve as cell surface receptors for hormones

2003

170. Which equation relates the standard free energy change (ΔG°) to the equilibrium constant (Keq)?
(A) $\Delta G^{\circ} = -RT\ln(Keq)$
(B) $\Delta G^{\circ} = RT\log(Keq)$
(C) $\Delta G^{\circ} = \Delta H - T\Delta S$
(D) $\Delta G^{\circ} = -nF\Delta E^{\circ}$

2004

171. Identify the INCORRECT statement regarding the biophysical properties of water.
(A) Water reaches its maximum density at 4 degrees Celsius.
(B) It acts as a temperature buffer in living organisms.
(C) The heat of vaporization of water is exceptionally low.
(D) Hydrogen bonds in ice form a rigid, open lattice structure.

2003

172. Match the items in List I with those in List II:
List I: Subcellular fractionation technique
P. Isopycnic centrifugation
Q. Differential centrifugation
R. Cell lysis
S. Rate-zonal centrifugation
List II: Medium
1. Sucrose density gradient (continuous)
2. Cesium chloride or Percoll gradient
3. Homogeneous isotonic sucrose buffer
4. Hypotonic buffer
(A) P-2, Q-3, R-4, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-1, R-2, S-3

2011

173. The term 'partial specific volume' ($\bar{v}$) is critical in which biophysical measurement?
(A) Calculating molecular weight from ultracentrifugation data
(B) Determining enzyme kinetics
(C) Measuring the absorbance of a solution
(D) Titrating a weak acid

2011

174. Which process best describes the transport of a solute against its concentration gradient coupled to the transport of another solute down its gradient?
(A) Secondary active transport
(B) Primary active transport
(C) Facilitated diffusion
(D) Osmosis

2022

175. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Ultrafiltration can be used to separate proteins from small molecule contaminants like salts.
Reason (R): Ultrafiltration membranes have specific molecular weight cut-offs that retain large proteins while allowing water and small salts to pass under pressure.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

176. Consider the following features regarding a eukaryotic cell:
I. 80S ribosomes in the cytosol.
II. Nucleoid region for DNA.
III. Linear chromosomes.
IV. Peptidoglycan cell wall.
Which of the above statement(s) is/are correct?
(A) I and III
(B) II and IV
(C) I, II and III
(D) I, III and IV

2009

177. Which statement about the protein buffer system is most accurate?
(A) Histidine side chains are the major contributors to buffering near physiological pH.
(B) It operates exclusively in the blood plasma.
(C) It relies heavily on the carboxyl groups of

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aspartate at pH 7.4.
(D) It is ineffective inside cells compared to outside.

2024

178. Arrange the following organelle fractions in the order they typically pellet during differential centrifugation (lowest to highest speed):
I. Microsomes
II. Nuclei
III. Mitochondria
(A) II, III, I
(B) III, II, I
(C) I, II, III
(D) II, I, III

2001

179. What causes the phenomenon of a 'streaming potential' in biophysics?
(A) Forcing a liquid containing ions through a capillary or porous solid, separating charges.
(B) Applying an electric field to a stationary gel.
(C) The sedimentation of heavy particles in a centrifuge.
(D) The diffusion of uncharged particles across a membrane.

2005

180. Which component is entirely absent from the inner mitochondrial membrane?
(A) ATP synthase
(B) Cardiolipin
(C) Cholesterol
(D) Electron transport chain complexes

2010

181. Match the items in List I with those in List II:
List I: Indicator
P. Phenolphthalein
Q. Methyl orange
R. Bromothymol blue
S. Universal indicator
List II: Use or property
1. Changes color around pH 3.1 - 4.4
2. Changes color around pH 6.0 - 7.6
3. Changes color around pH 8.2 - 10.0
4. Provides a continuous color change across a wide pH range
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-1, S-4
(D) P-4, Q-1, R-2, S-3

2019

182. A red blood cell is placed in an unknown solution and observed to shrink and crenate. The solution is therefore:
(A) Hypertonic
(B) Isotonic
(C) Hypotonic
(D) Iso-osmotic

2011

183. Identify the INCORRECT statement about the Golgi apparatus.
(A) It receives transport vesicles from the ER at its cis face.
(B) It modifies N-linked oligosaccharides on glycoproteins.
(C) It synthesizes lipids for the cell.
(D) It packages proteins into secretory vesicles.

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2009

184. Consider the following statements regarding the components found in a typical animal cell plasma membrane:
I. Phospholipids.
II. Cellulose.
III. Glycoproteins.
IV. Cholesterol.
V. Peptidoglycan.
Which of the above statement(s) is/are correct?
(A) I, III and IV
(B) I, II and IV
(C) II, III and V
(D) I, IV and V

2010

185. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The pH of blood remains tightly controlled despite the continuous production of metabolic acids.
Reason (R): Blood contains highly effective buffer systems, and excess acid equivalents are excreted by the lungs and kidneys.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

186. Which equation mathematically defines the ionic product of water (K_w)?

(A) $K_w = [H^+][OH^-]$
(B) $K_w = \frac{[H^+]}{[OH^-]}$
(C) $K_w = pH + pOH$
(D) $K_w = [H^+] + [OH^-]$

2025

187. The movement of solutes through a dialysis membrane is primarily driven by:
(A) Concentration gradient
(B) Hydrostatic pressure
(C) Electric potential
(D) Centrifugal force

2017

188. Which lipid is most prominent in the specialized membrane microdomains known as lipid rafts?
(A) Sphingolipids and cholesterol
(B) Phosphatidylcholine
(C) Phosphatidylserine
(D) Cardiolipin

2025

189. Which property describes the ability of a liquid to flow and is defined as internal friction?
(A) Surface tension
(B) Viscosity
(C) Specific heat
(D) Density

2003

190. Arrange the following steps in the mechanism of the Na^+/K^+ ATPase pump in the correct sequence:
I. ATP binds to the pump and is hydrolyzed, phosphorylating the pump.
II. 3 Na^+ ions bind to the intracellular sites of the pump.
III. 2 K^+ ions bind to extracellular sites, leading to dephosphorylation.
IV. The pump changes conformation, releasing Na^+ outside.
(A) II, I, IV, III
(B) I, II, III, IV
(C) II, IV, I, III
(D) IV, III, II, I

2010

191. The concept of 'activity' in physical chemistry is introduced to account for:
(A) The complete dissociation of weak acids
(B) The insolubility of lipids in water
(C) The high surface tension of biological fluids
(D) Non-ideal behavior due to ion interactions

2007

192. Match the items in List I with those in List II:
List I: Biophysical process
P. Diffusion
Q. Osmosis
R. Ultrafiltration
S. Electrophoresis
List II: Driving force
1. Concentration gradient of solute
2. Chemical potential gradient of water
3. Hydrostatic pressure gradient
4. Electrical potential gradient
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2024

193. Identify the INCORRECT statement regarding the buffer capacity.
(A) It is maximum when pH equals pK_a.
(B) It depends on the absolute concentration of the buffer components.
(C) It represents the amount of strong acid or base needed to change the pH by one unit.
(D) It is independent of the buffer concentration.

2005

194. In a colloidal system, the continuous phase is referred to as the:
(A) Dispersion medium
(B) Dispersed phase
(C) Solute
(D) Coagulant

2001

195. Consider the following statements regarding the nuclear envelope:
I. It is a double membrane structure.
II. It is continuous with the rough endoplasmic reticulum.
III. It contains nuclear pores for transport.
IV. It degrades entirely during interphase.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

2024

196. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Lyophilic colloids are more stable

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than lyophobic colloids.
Reason (R): Lyophilic colloidal particles have a strong affinity for the dispersion medium and are highly solvated.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

197. Which of the following organelles is NOT enclosed by a double membrane?
(A) Nucleus
(B) Mitochondrion
(C) Chloroplast
(D) Lysosome

2010

198. The specific marker enzyme for the Golgi apparatus in subcellular fractionation studies is typically:
(A) Galactosyltransferase
(B) Succinate dehydrogenase
(C) Catalase
(D) Acid phosphatase

2007

199. According to the Henderson-Hasselbalch equation, if the pH is one unit below the pK_a of a weak acid, the ratio of [A-]/[HA] is:
(A) 10:1
(B) 1:10
(C) 1:1
(D) 1:100

2009

200. What is the fundamental principle of isopycnic ultracentrifugation?
(A) Particles separate based on size and shape alone.
(B) The solvent slowly evaporates, concentrating the solute.
(C) Particles move until they reach their buoyant density position.
(D) A strong electric field drives the separation of particles.

2012

201. Identify the INCORRECT statement about primary active transport.
(A) It utilizes metabolic energy directly from ATP.
(B) It moves substances against their electrochemical gradient.
(C) The Na^+/K^+ pump is a classic example.
(D) It includes the sodium-calcium exchanger (NCX).

2014

202. Match the items in List I with those in List II:
List I: Thermodynamic term
P. Enthalpy
Q. Entropy
R. Gibbs free energy
S. Osmotic pressure
List II: Physiological context
1. Total heat content of the system
2. Measure of disorder, driving the hydrophobic effect
3. Determines the spontaneity of a metabolic reaction
4. Colligative property regulating cell volume
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2004

203. Which cellular process primarily relies on the physical properties of the cytoskeleton rather than simple diffusion?
(A) Vesicular transport from the ER to the Golgi
(B) Gas exchange in the alveoli
(C) Movement of water through aquaporins
(D) Oxygen transport into mitochondria

2019

204. Arrange the following biologically relevant buffers in order of their typical operating pH (lowest to highest):
I. Gastric juice buffer environment
II. Intracellular phosphate buffer
III. Blood plasma bicarbonate buffer
(A) I, II, III
(B) III, II, I
(C) II, I, III
(D) I, III, II

2024

205. The van 't Hoff factor (i) is introduced into osmotic pressure calculations to correct for:
(A) The dissociation of electrolytes into multiple particles
(B) The temperature of the solution
(C) The atmospheric pressure
(D) The volume of the solvent

2013

206. Consider the following statements regarding aquaporins:

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I. They are integral membrane proteins.
II. They allow the rapid passage of water molecules.
III. They actively transport water using ATP.
IV. They prevent the passage of protons to maintain gradients.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2001

207. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): In size-exclusion chromatography, larger molecules elute before smaller molecules.
Reason (R): Larger molecules cannot enter the pores of the stationary phase beads and traverse a shorter path through the column.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

208. Which component is largely responsible for the negative charge on the extracellular surface of most animal cells?
(A) Sialic acid residues on glycoproteins and glycolipids
(B) Cholesterol
(C) Phosphatidylcholine
(D) Cytosolic actin filaments

2008

209. The diffusion coefficient of a spherical molecule in solution is inversely proportional to its:
(A) Charge
(B) Radius
(C) Temperature
(D) Concentration

2012

210. Identify the INCORRECT statement regarding the isoelectric point (pI) of a protein.
(A) It is the pH at which the net charge of the protein is zero.
(B) The protein will migrate rapidly toward the anode at its pI during electrophoresis.
(C) Proteins are least soluble at their pI.
(D) Precipitation of proteins is often most effective at the pI.

2006

211. Which acid-base theory states that an acid is an electron pair acceptor?
(A) Arrhenius theory
(B) Lewis theory
(C) Brønsted-Lowry theory
(D) Pearson's HSAB theory

2024

212. Match the items in List I with those in List II:
List I: Membrane transport protein
P. $GLUT_4$
Q. CFTR
R. $SGLT_1$
S. V-type ATPase
List II: Specific function
1. Insulin-dependent glucose transport
2. Chloride ion channel
3. Sodium-glucose symport
4. Proton pumping into lysosomes
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2019

213. A solution containing 0.1 M NaCl and 0.1 M $CaCl_2$ has an ionic strength of:
(A) 0.4 M
(B) 0.2 M
(C) 0.3 M
(D) 0.5 M

2011

214. Which biophysical phenomenon restricts the movement of very large macromolecules across the capillary wall?
(A) Steric hindrance and pore size
(B) Simple diffusion
(C) Active transport
(D) Osmosis

2012

215. Consider the following statements regarding cell lysis techniques:
I. Detergents solubilize cell membranes by forming micelles with lipids.
II. Sonication shears DNA, which decreases extract viscosity.
III. Osmotic shock is highly effective for thick-walled plant cells.
Which of the above statement(s) is/are correct?

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(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2001

216. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Glycolipids are localized exclusively on the extracellular leaflet of the plasma membrane.
Reason (R): The enzymes responsible for adding carbohydrate residues to lipids are located in the lumen of the Golgi apparatus.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

217. In the context of dialysis, which material is most commonly used to manufacture semipermeable dialysis tubing?
(A) Polyethylene
(B) Regenerated cellulose
(C) Teflon
(D) Polycarbonate

2019

218. The ability of water molecules to stick to each other due to hydrogen bonding is termed:
(A) Cohesion
(B) Adhesion
(C) Surface tension
(D) Capillary action

2023

219. Identify the INCORRECT statement regarding the sedimentation of macromolecules.
(A) Larger mass generally leads to faster sedimentation.
(B) Higher solvent density increases the sedimentation rate.
(C) A more compact shape increases the sedimentation coefficient.
(D) Sedimentation velocity depends on the angular velocity of the rotor.

2011

220. Arrange the following steps in the action of a G-protein coupled receptor (GPCR) in the correct sequence:
I. Ligand binds to the receptor.
II. G-protein exchanges GDP for GTP.
III. Alpha subunit dissociates and activates an effector enzyme.
IV. GTP is hydrolyzed to GDP.
(A) I, II, III, IV
(B) II, I, III, IV
(C) I, III, II, IV
(D) IV, I, II, III

2004

221. Which thermodynamic parameter relates to the measure of randomness or disorder in a biological system?
(A) Enthalpy
(B) Entropy
(C) Free energy
(D) Internal energy

NODIA

2010

222. Match the items in List I with those in List II:
List I: Lipid structure
P. Micelle
Q. Liposome
R. Bilayer
S. Chylomicron
List II: Description
1. Monolayer sphere with hydrophobic core
2. Spherical vesicle with an aqueous core enclosed by a lipid bilayer
3. Planar two-leaflet sheet
4. Lipoprotein particle for dietary lipid transport
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2018

223. The transport of glucose into the intestinal epithelial cell against its concentration gradient is driven by the downhill movement of:
(A) Sodium ions
(B) Potassium ions
(C) Calcium ions
(D) Protons

2017

224. Which condition results in a left shift of the oxygen-hemoglobin dissociation curve, indicating higher affinity?
(A) Decreased pCO_2

(B) Increased body temperature
(C) Decreased pH (Bohr effect)
(D) Increased 2,3-BPG concentration

2014

225. Consider the following statements concerning lysosomes:
I. They function optimally at an acidic pH.
II. They are involved in the degradation of extracellular material taken up by endocytosis.
III. They lack a protective membrane.
IV. They are synthesized directly in the cytosol.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and IV
(D) III and IV

2009

226. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The dielectric constant of a solvent heavily influences the strength of ionic interactions within it.
Reason (R): According to Coulomb's law, the force between two charges is inversely proportional to the dielectric constant of the medium.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

227. The principle of the glass electrode used in a pH meter is based on measuring the potential difference across a thin membrane selectively permeable to:
(A) Hydrogen ions
(B) Sodium ions
(C) Chloride ions
(D) Potassium ions

2006

228. Identify the INCORRECT statement regarding the Langmuir adsorption isotherm.
(A) It accurately models multilayer adsorption.
(B) It assumes all sites are energetically equivalent.
(C) It assumes no interactions between adsorbed molecules.
(D) At low concentrations, adsorption is proportional to concentration.

2021

229. Which biophysical term describes the partial specific volume of a protein in solution?
(A) Increase in solution volume per unit mass of added protein
(B) The volume of the dry protein powder
(C) The total volume of the solution
(D) The volume of the solvent minus the volume of the solute

2024

230. Arrange the following molecules in order of their increasing percentage contribution to the dry weight of a typical animal cell:
I. Carbohydrates
II. Lipids
III. Proteins
(A) I, II, III
(B) II, I, III
(C) I, III, II
(D) III, II, I

2016

231. Which of the following organelles is NOT directly involved in the synthesis or modification of cellular proteins?
(A) Rough Endoplasmic Reticulum
(B) Smooth Endoplasmic Reticulum
(C) Golgi Apparatus
(D) Ribosomes

2015

232. Match the items in List I with those in List II:
List I: Characteristic feature
P. Absence of membrane-bound organelles
Q. Presence of cholesterol in cell membrane
R. Presence of peptidoglycan cell wall
S. Exclusively unicellular
List II: Cell type
1. Eukaryotic animal cell
2. Prokaryotic bacterial cell
(A) P-1, Q-2, R-1, S-1
(B) P-2, Q-2, R-1, S-1
(C) P-1, Q-1, R-2, S-2
(D) P-2, Q-1, R-2, S-2

2004

233. The 'salting out' of proteins from a solution upon the addition of a high concentration of ammonium sulfate is primarily due to:
(A) Competition for water of hydration between

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the protein and the salt ions
(B) Denaturation of the protein structure
(C) Covalent binding of sulfate to the protein
(D) Complete neutralization of the protein's surface charge

2021

234. In the derivation of the Henderson-Hasselbalch equation, the term [A-] refers to the concentration of:
(A) The conjugate base
(B) The weak acid
(C) The strong acid
(D) The hydrogen ion

2011

235. Consider the following statements regarding Brownian motion:
I. It is caused by the continuous, random bombardment of colloidal particles by solvent molecules.
II. It opposes the gravitational settling of small particles.
III. It ceases entirely at 25 degrees Celsius.
IV. It is more pronounced for smaller particles and in less viscous solvents.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2012

236. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The fluid mosaic model describes cell membranes as rigid, two-dimensional structures.
Reason (R): Phospholipids in a biological membrane can undergo rapid lateral diffusion.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

237. Which of the following factors does NOT significantly influence the rate of facilitated diffusion?
(A) Availability of ATP in the cytoplasm
(B) Concentration gradient of the solute
(C) Number of available carrier proteins
(D) Affinity of the carrier for the solute

2003

238. Identify the INCORRECT statement about the function of normal physiological buffers.
(A) They resist large changes in pH upon the addition of small amounts of acid or base.
(B) They permanently neutralize and remove excess acid from the body.
(C) They consist of a weak acid and its conjugate base.
(D) They are most effective when the pH is exactly equal to the pKa.

2009

239. The process of ultrafiltration is best described as:
(A) Pressure-driven separation of molecules through a semipermeable membrane based on size
(B) Separation of particles based on their density in a centrifugal field
(C) Spontaneous movement of solute down a concentration gradient
(D) Movement of charged particles in an electrical field

2013

240. Arrange the following stages of cellular fractionation by differential centrifugation in correct chronological order:
I. Pellet contains unbroken cells and nuclei.
II. Pellet contains microsomes.
III. Pellet contains mitochondria and lysosomes.
IV. Supernatant contains soluble cytosolic proteins.
(A) I, III, II, IV
(B) I, II, III, IV
(C) III, I, II, IV
(D) II, III, I, IV

NODIA

2024

241. Which physical property of water is primarily responsible for its high surface tension?
(A) Extensive hydrogen bonding
(B) Low molecular weight
(C) V-shaped molecular geometry
(D) Ability to act as an amphoteric substance

2005

242. Which condition is characterized by a blood pH above 7.45 and a decrease in pCO_2?
(A) Metabolic acidosis
(B) Respiratory alkalosis

(C) Respiratory acidosis
(D) Metabolic alkalosis

2015

243. The zeta potential of a stable colloidal dispersion is typically:
(A) Highly positive or highly negative, preventing coagulation
(B) Exactly zero
(C) Irrelevant to the stability of the colloid
(D) Equal to the Nernst potential

2018

244. A molecule that can act as both an acid and a base is termed:
(A) Amphoteric
(B) Amphipathic
(C) Zwitterionic
(D) Isomeric

2025

245. Consider the following statements concerning the properties of biological membranes:
I. They are structurally asymmetric.
II. They are selectively permeable.
III. They undergo phase transitions dependent on temperature and lipid composition.
IV. They are freely permeable to large, water-soluble molecules.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I, III and IV

2010

246. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Mitochondria are often referred to as the powerhouses of the cell.
Reason (R): They are the primary site of oxidative phosphorylation and ATP generation in eukaryotic cells.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

247. The rate of sedimentation of a particle in an ultracentrifuge is not dependent on which of the following?
(A) Chemical composition of the centrifuge tube
(B) Density of the particle
(C) Density of the solvent
(D) Viscosity of the solvent

2019

248. Identify the INCORRECT statement regarding the Gibbs-Donnan equilibrium.
(A) Diffusible cation concentration equals anion concentration on protein side.
(B) It applies when a membrane is permeable to some but not all ions in a solution.
(C) It results in an electrical potential difference across the membrane.
(D) It influences the osmotic pressure of the cell.

2023

249. Which of the following represents a disadvantage of using dialysis to concentrate a dilute protein solution?
(A) It is generally a very slow process.
(B) It subjects the protein to high shear stress.
(C) It requires highly expensive centrifugation equipment.
(D) It irreversibly denatures all enzymes.

2006

250. Arrange the following steps in preparing a density gradient for isopycnic centrifugation in the correct sequence:
I. Layer the sample carefully on top.
II. Prepare a solution with a continuous concentration gradient of sucrose or CsCl.
III. Collect fractions from the tube after separation.
IV. Centrifuge until particles reach their equilibrium density position.
(A) II, I, IV, III
(B) I, II, III, IV
(C) II, IV, I, III
(D) IV, II, I, III

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2025

251. The unique ability of carbon atoms to form long, stable chains and rings, foundational to biochemistry, is termed:
(A) Catenation
(B) Isomerization
(C) Polymerization
(D) Hybridization

2015

252. Match the items in List I with those in List II:
List I: Subcellular component
P. Nucleolus
Q. Cytosol
R. Plasma membrane
S. Chromatin
List II: Predominant biochemical composition
1. RNA and proteins
2. Water, dissolved ions, and soluble proteins
3. Phospholipids, cholesterol, and proteins
4. DNA and histones
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2001

253. Which biophysical constant dictates the extent to which a substance resists changes in temperature when absorbing heat?
(A) Specific heat
(B) Latent heat
(C) Thermal conductivity
(D) Dielectric constant

2022

254. If a weak acid has a pK_a of 5.0, at what pH will it be 90% dissociated? (Hint: $\log(9)$ is approximately 0.95)
(A) 5.95
(B) 4.05
(C) 6.00
(D) 5.00

2019

255. Consider the following statements regarding biological light scattering:
I. Static light scattering measures average molecular weight.
II. Dynamic light scattering measures the clue to diffusion coefficient and hydrodynamic radius.
III. Light scattering intensity decreases as particle size increases.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2015

256. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): Secondary active transport depends on the continuous operation of primary active transport.
Reason (R): Primary active transport establishes and maintains the ion gradients that provide the driving force for secondary active transport.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

257. What is the fundamental mechanism by which a weak acid-base indicator changes color?
(A) Protonated and deprotonated forms have different absorption spectra.
(B) It undergoes radioactive decay at specific pH values.
(C) It evaporates when the solution becomes too acidic.
(D) It reacts irreversibly with the solvent to form a dye.

2001

258. Identify the INCORRECT statement concerning cellular homogenization methods.
(A) The Potter-Elvehjem homogenizer relies on shearing forces.
(B) Osmotic shock utilizes a hypertonic solution to burst cells.
(C) Sonication creates cavitation bubbles to disrupt membranes.
(D) French press uses high pressure followed by sudden release to shear cells.

2012

259. Which physical property of a colloidal system involves the scattering of a light beam, making its path visible?
(A) Tyndall effect
(B) Brownian motion
(C) Electrophoresis
(D) Coagulation

2001

260. Arrange the following biologically relevant units of length in increasing order of magnitude:
I. Nanometer (nm)
II. Angstrom (Å)
III. Micrometer (μm)
IV. Millimeter (mm)

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(A) II, I, III, IV
(B) I, II, III, IV
(C) III, II, I, IV
(D) II, III, I, IV

2007

261. The high latent heat of vaporization of water provides which primary physiological advantage to animals?
(A) Effective dissipation of excess body heat through sweating or panting
(B) Efficient transport of oxygen in the blood
(C) rapid conduction of nerve impulses
(D) Enhanced digestion of lipids in the gut

2022

262. Match the items in List I with those in List II:
List I: Type of membrane protein
P. Single-pass integral protein
Q. Multi-pass integral protein
R. Peripheral membrane protein
S. Lipid-anchored protein
List II: Characteristic interaction
1. Spans the bilayer exactly once via a hydrophobic alpha-helix
2. Weaves back and forth across the bilayer multiple times
3. Associates loosely with the membrane surface via non-covalent bonds
4. Covalently attached to a lipid molecule embedded in the bilayer
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2018

263. A solution containing red blood cells is diluted with pure water. What is the expected physiological outcome?
(A) Hemolysis
(B) Crenation
(C) Plasmolysis
(D) No change

2008

264. What is the principal buffer system operating in the interstitial fluid of animals?
(A) Bicarbonate buffer
(B) Phosphate buffer
(C) Protein buffer
(D) Acetate buffer

2011

265. Consider the following statements defining a eukaryotic nucleus:
I. Surrounded by a double membrane with pores.
II. Contains the nucleolus, the site of ribosome assembly.
III. Harbors the cell's genetic material in the form of linear chromosomes.
IV. Synthesizes ATP directly via glycolysis.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

NODIA

2017

266. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The Na^+/K^+ pump is considered an electrogenic pump.
Reason (R): It extrudes three positive charges (Na^+) for every two positive charges (K^+) it brings into the cell, generating a net outward current.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

267. Which of the following explains why pure water is a poor conductor of electricity?
(A) It has a very low degree of ionization.
(B) It lacks any dipoles.
(C) It is too viscous to allow ion movement.
(D) It spontaneously forms a highly structured ice lattice at room temperature.

2008

268. Identify the INCORRECT statement regarding simple diffusion across a cell membrane.
(A) It requires specialized transport proteins.
(B) It is driven by the concentration gradient.
(C) Small, nonpolar molecules diffuse most readily.
(D) It does not require the expenditure of metabolic energy.

2015

269. Which biophysical law dictates that the amount of gas dissolved in a liquid is proportional to its partial pressure above the liquid?

(A) Henry's law
(B) Boyle's law
(C) Charles's law
(D) Raoult's law

2011

270. Arrange the following cellular compartments in order from the most acidic to the most alkaline typical internal pH:
I. Lysosome
II. Cytosol
III. Mitochondrial matrix
(A) I, II, III
(B) III, II, I
(C) I, III, II
(D) II, I, III

2004

271. The phenomenon of a liquid rising or falling in a narrow tube due to surface tension and adhesive forces is called:
(A) Capillarity
(B) Viscosity
(C) Syneresis
(D) Peptization

2003

272. Match the items in List I with those in List II:
List I: Enzyme
P. Acid phosphatase
Q. Catalase
R. Cytochrome c oxidase
S. RNA polymerase
List II: Biological function or cellular location
1. Lysosomal degradation
2. Peroxisomal hydrogen peroxide detoxification
3. Mitochondrial electron transport
4. Nuclear transcription
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2005

273. The formula $pH = pKa + \log\frac{[Base]}{[Acid]}$ is universally known as the:
(A) Henderson-Hasselbalch equation
(B) Nernst equation
(C) Michaelis-Menten equation
(D) Lineweaver-Burk equation

2005

274. Which of the following represents a disadvantage of using dialysis to concentrate a dilute protein solution?
(A) It is generally a very slow process.
(B) It subjects the protein to high shear stress.
(C) It requires highly expensive centrifugation equipment.
(D) It irreversibly denatures all enzymes.

2012

275. Consider the following statements concerning the properties of a typical colloidal dispersion:
I. Particles pass through ordinary filter paper.
II. Particles are visible under a standard light microscope.
III. They exhibit the Tyndall effect.
IV. Particles settle rapidly under standard gravity.
Which of the above statement(s) is/are correct?
(A) I and III
(B) II and IV
(C) I, II and III
(D) II, III and IV

2002

276. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): During ultracentrifugation, the sedimentation rate of a macromolecule increases as the rotor speed increases.
Reason (R): The centrifugal force applied to the macromolecule is proportional to the square of the angular velocity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

277. The term 'amphoteric' is best applied to which of the following biological molecules?
(A) Amino acids
(B) Glucose
(C) Triglycerides
(D) Cholesterol

2022

278. Identify the INCORRECT statement regarding the calculation of ionic strength.
(A) It is completely independent of the valency of the ions.
(B) It accounts for both the concentration and the charge of all ions in the solution.
(C) Monovalent ions contribute less to ionic

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strength than multivalent ions at the same concentration.
(D) It is essential for determining the activity coefficients of ions in a non-ideal solution.

2024

279. Which mathematical expression defines the activity coefficient (γ) of an ion?
(A) Ratio of activity to concentration
(B) Product of activity and concentration
(C) Ratio of concentration to activity
(D) Sum of activity and concentration

2019

280. Arrange the sequence of events in a typical receptor-mediated endocytosis pathway:
I. Ligand binds to specific cell surface receptors.
II. Receptor-ligand complexes cluster in clathrin-coated pits.
III. The pit invaginates to form a coated vesicle.
IV. The vesicle uncoats and fuses with an endosome.
(A) I, II, III, IV
(B) II, I, III, IV
(C) III, I, II, IV
(D) I, III, II, IV

2015

281. The process of removing low molecular weight solutes from a solution of macromolecules by allowing them to diffuse through a semipermeable membrane into a large volume of buffer is:
(A) Dialysis
(B) Electrophoresis
(C) Ultracentrifugation
(D) Chromatography

2005

282. Match the items in List I with those in List II:
List I: Cell junction type
P. Tight junctions
Q. Desmosomes
R. Gap junctions
S. Hemidesmosomes
List II: Primary physiological function
1. Seal adjacent cells to prevent fluid leakage
2. Anchor cells together mechanically to resist shearing
3. Provide cytoplasmic channels for intercellular communication
4. Anchor cells to the extracellular matrix or basal lamina
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2022

283. In the context of acid-base balance, a patient exhibiting a lower-than-normal blood pH and elevated pCO_2 is most likely suffering from:
(A) Respiratory acidosis
(B) Metabolic acidosis
(C) Metabolic alkalosis
(D) Respiratory alkalosis

2009

284. Which parameter is a measure of the effective osmotic pressure exerted by a solution across a perfect semipermeable membrane?
(A) Tonicity
(B) Viscosity
(C) Surface tension
(D) Dielectric constant

2024

285. Consider the following statements regarding the biophysical constant 'S' (Svedberg):
I. It is not strictly additive (e.g., 40S + 60S = 80S in eukaryotes).
II. It measures the sedimentation velocity per unit centrifugal field.
III. It depends only on the mass of the particle, not its shape.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

NODIA

2014

286. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:
Assertion (A): The inner leaflet of the plasma membrane typically has a higher concentration of phosphatidylserine compared to the outer leaflet.
Reason (R): Flippases selectively transport phosphatidylserine and phosphatidylethanolamine from the outer leaflet to the inner leaflet using ATP.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

287. Which physical principle states that light passing through a colloidal dispersion is scattered by the dispersed particles?
(A) Rayleigh-Tyndall effect
(B) Faraday effect
(C) Doppler effect
(D) Zeeman effect

2005

288. Identify the INCORRECT statement regarding the composition of the cytosol.
(A) It is entirely devoid of structural elements.
(B) It is an aqueous gel-like substance.
(C) It contains a high concentration of dissolved proteins and enzymes.
(D) It is the site of glycolysis and fatty acid synthesis.

2013

289. Which mechanism represents the primary mode of bulk transport of macromolecules OUT of a eukaryotic cell?
(A) Exocytosis
(B) Endocytosis
(C) Active transport via pumps
(D) Facilitated diffusion

2025

290. Arrange the following steps of an enzyme-catalyzed reaction in the correct order:
I. Substrate binds to the enzyme's active site.
II. Enzyme-substrate complex is formed.
III. Transition state is reached and reaction occurs.
IV. Products are released from the active site.
(A) I, II, III, IV
(B) II, I, III, IV
(C) I, III, II, IV
(D) III, I, II, IV

2008

291. Which property of water is most directly responsible for the efficient cooling effect of sweating in animals?
(A) High heat of vaporization
(B) High specific heat
(C) High dielectric constant
(D) High surface tension

2011

292. Match the items in List I with those in List II:
List I: Subcellular fractionation term
P. Homogenate
Q. Supernatant
R. Pellet
S. Gradient
List II: Definition
1. The complete, un-fractionated mixture of disrupted cells
2. The liquid lying above a solid residue after centrifugation
3. The solid residue at the bottom of a tube after centrifugation
4. A solution varying continuously in density from top to bottom
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

2022

293. The Donnan equilibrium generally leads to an increase in intracellular osmotic pressure. How do typical animal cells counteract this to prevent swelling and lysis?
(A) By actively pumping out ions, primarily via the Na^+/K^+ ATPase
(B) By maintaining a rigid cell wall
(C) By converting all internal proteins into insoluble aggregates
(D) By actively pumping water out via aquaporins

2006

294. What is the fundamental basis of size exclusion chromatography (gel filtration)?
(A) Separation based on the molecule's ability to enter the pores of a stationary phase matrix
(B) Separation based on the net surface charge of the molecule
(C) Separation based on specific binding affinity to a ligand
(D) Separation based on the hydrophobicity of the molecule

2006

295. Consider the following statements concerning fluid viscosity:
I. Viscosity is a measure of a fluid's resistance to deformation or flow.
II. The viscosity of blood increases significantly as hematocrit increases.
III. Viscosity of liquids generally increases with increasing temperature.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

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2009

296. Each of the following questions consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the codes given below:

Assertion (A): In biological membranes, lipid molecules rarely flip-flop spontaneously from one leaflet to the other.

Reason (R): Transverse diffusion (flip-flop) requires the polar head group of the lipid to pass through the highly hydrophobic core of the bilayer, which is energetically highly unfavorable.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

297. Which analytical technique measures the rate at which macromolecules move under the influence of a strong centrifugal force to determine their mass and shape?

(A) Analytical ultracentrifugation
(B) Gas chromatography
(C) X-ray crystallography
(D) Mass spectrometry

2024

298. Identify the INCORRECT statement about the physiological role of cholesterol.

(A) It is a component of the inner mitochondrial membrane.
(B) It is a precursor for steroid hormone synthesis.
(C) It is a precursor for bile acids.
(D) It modulates the fluidity of the plasma membrane.

2007

299. In thermodynamics, the term 'osmotic pressure' is best defined as:

(A) The exact pressure required to stop the net flow of solvent across a semipermeable membrane
(B) The pressure exerted by blood against the arterial walls
(C) The pressure at which a liquid boils
(D) The physical pressure exerted by the cytoplasm against the cell membrane

NODIA

2011

300. Arrange the following steps for selecting a biochemical acid-base indicator for a specific titration:

I. Determine the pH at the equivalence point of the titration.
II. Identify an indicator whose pKa is close to the equivalence point pH.
III. Ensure the color change interval overlaps with the steep portion of the titration curve.
IV. Add a few drops of the chosen indicator to the analyte solution before titrating.

(A) I, II, III, IV
(B) II, I, III, IV
(C) III, I, II, IV
(D) I, III, II, IV

****

ANSWERS

1. (D) Biochemistry
Biochemistry investigates the complex chemical reactions and molecular interactions that occur within all living organisms. This scientific discipline merges principles of biology and chemistry to understand how biological molecules like proteins, nucleic acids, and lipids contribute to cellular function. It provides essential insights into metabolic pathways and the fundamental molecular basis of life processes.

2. (C) Bent
The water molecule possesses a bent or V-shaped geometry due to the presence of two lone pairs of electrons on the central oxygen atom. According to valence shell electron pair repulsion theory, these lone pairs exert greater repulsive forces than bonding pairs. This arrangement reduces the bond angle from the ideal tetrahedral angle to approximately one hundred four degrees.

3. (B) It applies only to aqueous solutions
The Brønsted-Lowry concept defines acids as proton donors and bases as proton acceptors. Unlike the earlier Arrhenius theory, which was restricted to aqueous environments, this model is applicable to reactions occurring in any solvent or even in the gas phase. It highlights the dynamic relationship between conjugate acid-base pairs, which differ solely by the presence of a single proton.

4. (D) P-2, Q-1, R-3, S-4
Physiological buffers are localized strategically throughout the body. The bicarbonate system is the primary buffer in blood plasma. Phosphate buffers predominantly manage pH within the intracellular fluid. Proteins serve as versatile buffers in both plasma and intracellular compartments due to their ionizable groups. Hemoglobin acts as a specialized buffer exclusively within red blood cells to handle carbon dioxide transport.

5. (A) Negative logarithm of hydrogen ion activity
The pH scale provides a logarithmic measure of the acidity or alkalinity of a solution. Mathematically, it is defined as the negative base ten logarithm of the effective concentration, known as activity, of hydrogen ions. This representation allows for the expression of widely varying hydrogen ion concentrations using a simple numerical range, typically spanning from zero to fourteen units.

6. (C) Henderson-Hasselbalch equation
The Henderson-Hasselbalch equation describes the quantitative relationship between the pH of a buffer solution, the dissociation constant of the weak acid, and the ratio of conjugate base to acid concentrations. It is a fundamental tool for predicting how buffers resist pH changes. This formula is essential in biological laboratories for preparing buffers at specific and stable physiological hydrogen ion levels.

7. (A) Both A and R are true and R is the correct explanation of A
The bicarbonate buffer system is essential for maintaining extracellular pH balance in mammals. Its effectiveness stems from its open nature, allowing the lungs to regulate carbon dioxide levels and the kidneys to manage bicarbonate concentration. These physiological mechanisms provide a robust way to respond to metabolic acid-base challenges, ensuring that internal homeostatic conditions remain within a narrow, life-sustaining range.

8. (D) Brownian motion
Brownian motion describes the continuous, random, and zigzag movement of colloidal particles suspended in a liquid or gas. This physical phenomenon results from the constant bombardment of the dispersed particles by the much smaller molecules of the dispersion medium. It plays a critical role in preventing the settling of particles due to gravity, thus maintaining the stability of colloids.

9. (B) Sphingolipids - Absent in neural tissues
Sphingolipids are actually highly concentrated in neural tissues, where they are critical components of the myelin sheath that insulates axons. Unlike phospholipids which use glycerol, sphingolipids are built upon a sphingosine backbone. They contribute significantly to membrane structural integrity and cell signaling. Stating that they are

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absent in the nervous system is incorrect as they are structurally vital.

10. (C) 3 Na^+ out and 2 K^+ in
The sodium-potassium ATPase pump is an integral membrane protein that performs primary active transport. In each catalytic cycle, it utilizes energy from the hydrolysis of one ATP molecule to export three sodium ions from the cell while importing two potassium ions. This stoichiometry creates an electrochemical gradient and helps maintain the resting membrane potential across the cell membrane.

11. (D) Rough ER, Golgi apparatus, Secretory vesicles, Plasma membrane
The secretory pathway involves a highly organized sequence of organelle interactions. Proteins are first synthesized and folded in the rough endoplasmic reticulum before being transported to the Golgi apparatus for modification and sorting. From there, they are packaged into secretory vesicles that move toward the cell exterior. Finally, these vesicles fuse with the plasma membrane to release their contents.

12. (A) van 't Hoff equation
The van 't Hoff equation describes the relationship between osmotic pressure and the concentration of solutes in a solution. It states that for dilute solutions, the osmotic pressure is directly proportional to the molar concentration of the solute and the absolute temperature. This principle is fundamental in biophysics for understanding how cells maintain volume and regulate water movement across membranes.

13. (B) Gibbs-Donnan equilibrium
The Gibbs-Donnan equilibrium occurs when a semipermeable membrane separates solutions containing diffusible ions and non-diffusible macromolecules like proteins. The presence of these trapped charged species forces an unequal distribution of the small ions at equilibrium to maintain electrical neutrality. This phenomenon creates a transmembrane potential and contributes to the higher osmotic pressure observed inside biological cells compared to their environment.

14. (B) It is entirely determined by plasma proteins
Blood viscosity is a complex rheological property influenced by several factors, not just plasma proteins. While proteins like fibrinogen contribute, the primary determinant is the volume percentage of red blood cells, known as the hematocrit. Blood behaves as a non-Newtonian fluid, meaning its viscosity changes with flow rate. It is significantly higher than water and affects total peripheral resistance.

15. (A) Monolayer coverage on homogeneous sites
The Langmuir adsorption isotherm is a theoretical model that assumes gas molecules adsorb onto a solid surface in a single layer. It presupposes that the surface contains a fixed number of identical, independent sites where only one molecule can bind per site. This model ignores interactions between neighboring adsorbed molecules, providing a simplified yet useful framework for studying surface chemistry.

16. (C) I and III
Fick's first law of diffusion states that the flux of a substance is directly proportional to its concentration gradient. This law applies to steady-state conditions where the concentration profile does not change over time. While temperature significantly influences the diffusion coefficient, the law itself relates flux and gradient. Statements regarding flux proportionality and steady-state application are scientifically accurate in this context.

17. (D) Dialysis
Dialysis is a separation technique that utilizes a semipermeable membrane to remove small solutes from a solution of macromolecules. It relies on the differential diffusion rates of molecules driven by a concentration gradient. Small ions and molecules pass through the membrane pores into a surrounding buffer, while larger proteins are retained. This method is widely used for desalting and purifying biological samples.

18. (C) P-2, Q-1, R-4, S-3
Specific enzymes serve as markers to identify subcellular organelles during fractionation. Acid phosphatase is characteristic of lysosomes, where it functions in acidic environments. Succinate dehydrogenase is a key component of the mitochondrial electron transport chain. Glucose-six-phosphatase is located within the endoplasmic reticulum membrane. Catalase is the primary enzyme used to identify peroxisomes, where it decomposes hydrogen peroxide.

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19. (B) Membrane-bound nucleus
Eukaryotic cells are distinguished from prokaryotic cells by the presence of a membrane-bound nucleus that houses the genetic material. While both cell types share ribosomes, a plasma membrane, and cytosol, only eukaryotes possess complex internal compartmentalization. This includes diversos organelles such as mitochondria and the endoplasmic reticulum, allowing for specialized metabolic activities to occur in distinct environments within the cell.

20. (A) I, II, III, IV
The sedimentation coefficient, measured in Svedberg units, reflects the rate at which particles settle during centrifugation based on mass and shape. Whole eukaryotic cells are the largest and sediment first, followed by nuclei. Mitochondria are smaller than nuclei and have intermediate coefficients. Ribosomes are the smallest macromolecular complexes among these choices, resulting in the lowest sedimentation coefficient in the series.

21. (A) Peroxisome
Peroxisomes are specialized metabolic organelles responsible for the alpha and beta-oxidation of very long-chain fatty acids. Unlike the mitochondria, which handle shorter chains, peroxisomes initiate the breakdown of these large lipids until they are short enough for further processing. This activity is vital for lipid homeostasis and produces hydrogen peroxide as a byproduct, which is then neutralized by catalase.

22. (C) Isopycnic ultracentrifugation
Isopycnic ultracentrifugation separates particles based exclusively on their buoyant density rather than their size or shape. During this process, a density gradient is established, and particles migrate until they reach the position where their density matches that of the surrounding medium. This technique is highly effective for isolating specific organelles or macromolecules that have similar sizes but distinct chemical compositions.

23. (A) Both A and R are true and R is the correct explanation of A
Water possesses an exceptionally high dielectric constant because its molecules have a strong dipole moment. This characteristic arises from the electronegativity difference between oxygen and hydrogen, creating a polar structure. The high dielectric constant allows water to effectively screen the electrostatic attractions between dissolved ions, making it a superior solvent for ionic compounds and polar biological molecules in living systems.

24. (D) Electron pair acceptor
The Lewis theory provides a broad definition of acids and bases based on electron movement. A Lewis acid is a chemical species that can accept a pair of electrons from a donor molecule to form a covalent bond. This definition encompasses many substances that do not contain hydrogen, expanding the classification beyond the proton-centric models of Arrhenius and Brønsted-Lowry.

25. (B) Activity
Activity represents the effective concentration of a species in a solution, accounting for non-ideal behaviors caused by interionic interactions. In dilute solutions, activity is approximately equal to molarity, but in concentrated biological fluids, these values diverge. The activity coefficient is used to relate activity to the actual concentration, ensuring accurate calculations in thermodynamics and chemical equilibrium studies within living organisms.

26. (C) Scattering of light by particles
The Tyndall effect is the phenomenon where a beam of light becomes visible as it passes through a colloidal dispersion. This occurs because the colloidal particles are large enough to scatter the incident light rays in various directions. True solutions do not exhibit this effect because their solute particles are too small to interact significantly with the wavelength of visible light.

27. (D) Secondary active transport is independent of ion gradients
Secondary active transport is fundamentally dependent on ion gradients established by primary active transport. It uses the potential energy stored in an electrochemical gradient, such as that of sodium or protons, to drive the movement of another molecule against its own concentration gradient. This process does not directly hydrolyze ATP but relies on the energy already expended to maintain the gradient.

28. (D) II and III
Animal cell membranes are dynamic structures where cholesterol plays a vital role in modulating fluidity across varying temperatures. Peripheral

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proteins are located on the membrane surface and are attached via relatively weak non-covalent interactions. Carbohydrates are found on the extracellular surface, not the intracellular side, and phosphatidylserine is typically sequestered in the inner leaflet, making the second and third statements correct.

29. (B) $I = \frac{1}{2}\sum c_i z_i^2$
The ionic strength of a solution is a measure of the total concentration of ions, weighted by the square of their electrical charges. It is calculated by summing the product of each ion's molar concentration and the square of its charge, then dividing the total by two. This parameter is crucial for determining activity coefficients and understanding electrostatic interactions in biological fluids.

30. (B) Isotonic
An isotonic solution has an osmotic pressure equal to that of the intracellular fluid. When a cell is placed in such a medium, there is no net movement of water across the plasma membrane, allowing the cell to maintain its normal volume and shape. This balance is critical for medical intravenous fluids to ensure they do not cause red blood cells to shrink or burst.

31. (B) Hydrostatic pressure gradient
Ultrafiltration is a pressure-driven separation process where a solution is forced through a semipermeable membrane. The driving force is a hydrostatic pressure gradient that pushes water and small solutes through the membrane pores while retaining larger macromolecules. This mechanism is essential in both industrial protein concentration and physiological processes, such as the initial stage of urine formation in the kidneys.

32. (A) Surfactant
Pulmonary surfactant is a complex mixture of lipids and proteins produced by alveolar cells. Its primary function is to significantly reduce the surface tension at the air-liquid interface within the lung alveoli. By lowering surface tension, surfactant prevents the collapse of small alveoli during expiration and reduces the work required to expand the lungs during inspiration, ensuring efficient gas exchange.

33. (A) P-3, Q-1, R-2, S-4
The unique physical properties of water are vital for life. Its high specific heat allows organisms to resist rapid temperature changes. The high latent heat of vaporization enables efficient evaporative cooling through sweating. A high dielectric constant facilitates the dissolution of ionic compounds. Furthermore, extensive hydrogen bonding creates cohesive forces and surface tension, supporting various biological structures and transport mechanisms.

34. (A) Indicator pKa matches pH at the equivalence point
Choosing a suitable acid-base indicator requires matching the indicator's pKa to the pH expected at the titration's equivalence point. Indicators undergo a visible color change within a specific pH range, typically spanning one unit above and below their pKa. A proper match ensures that the color transition occurs precisely when the stoichiometric amounts of acid and base have reacted together.

35. (A) Both A and R are true and R is the correct explanation of A
Glycolysis is the initial metabolic pathway for glucose degradation and occurs entirely within the cytosol of eukaryotic cells. This localization is maintained because all the required enzymes for the ten sequential steps of glycolysis are present in the cytosolic compartment and absent from the mitochondria. This spatial organization allows the cell to regulate carbohydrate metabolism independently of the aerobic processes in mitochondria.

36. (C) Square of the radius of the particle
According to Stokes' Law, the sedimentation rate of a spherical particle in a centrifugal field is directly proportional to the square of its radius. This means that even small increases in particle size lead to significantly faster sedimentation velocities. This relationship is fundamental to centrifugal separation techniques, allowing for the efficient isolation of various cellular components based on their different physical dimensions.

37. (C) Mechanical homogenization (e.g., Potter-Elvehjem)
Mechanical homogenization is the most appropriate method for disrupting tough tissues like muscle during subcellular fractionation. Devices such as the Potter-Elvehjem homogenizer

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use a rotating plunger to create high shear forces that break open cell membranes while keeping organelles relatively intact. Other methods, like osmotic shock or mild detergents, are often insufficient for the fibrous and resilient structure of muscle tissue.

38. (D) It is the potential at the slipping plane of a colloidal particle
Zeta potential is defined as the electrical potential at the slipping plane, which is the boundary where the liquid layer moves with the colloidal particle relative to the bulk solvent. It is not the potential at the actual particle surface but rather reflects the net charge within the surrounding ion layer. A high zeta potential indicates strong electrostatic repulsion, which prevents particle coagulation.

39. (B) Sodium-glucose symporter in the intestine
The sodium-glucose symporter is a classic example of secondary active transport. This mechanism does not use ATP directly but instead utilizes the energy provided by the sodium gradient, which was previously established by the Na^+/K^+ ATPase. As sodium ions move down their concentration gradient into the cell, the symporter couples this movement to transport glucose molecules against their concentration gradient simultaneously.

40. (A) Lag, Log, Stationary, Death
A typical bacterial growth curve follows four distinct phases. The lag phase involves metabolic adjustment without division. The log or exponential phase is characterized by rapid, constant cell division. During the stationary phase, nutrient depletion and waste accumulation cause the growth rate to equal the death rate. Finally, in the death phase, the number of living cells declines as conditions become unsustainable.

41. (A) The pH at which it is half-dissociated
The pKa of an acid is the negative logarithm of its acid dissociation constant. Functionally, it represents the specific pH at which the concentrations of the protonated acid and its conjugate base are exactly equal. At this point, the acid is fifty percent dissociated. This value is a critical parameter for determining the strength of an acid and its effectiveness as a buffer.

42. (A) Sphingosine
Sphingomyelin is a major component of animal cell membranes, particularly the myelin sheath of nerve cells. Unlike many other membrane lipids that use glycerol as a structural foundation, sphingomyelin is built upon a sphingosine backbone. This long-chain amino alcohol is covalently attached to a fatty acid via an amide bond and to a phosphocholine group, forming the complete sphingolipid molecule.

43. (D) Ribosome biogenesis
The nucleolus is a dense, non-membrane-bound sub-compartment within the nucleus of eukaryotic cells. Its primary role is the synthesis of ribosomal RNA and the assembly of ribosomal subunits. This process involves the transcription of rRNA genes, processing of the resulting transcripts, and their association with specific proteins to form the large and small subunits required for protein translation in the cytosol.

44. (A) I, II and IV
The Golgi apparatus is a central hub for protein processing, consisting of distinct cis, medial, and trans cisternae. It is responsible for the complex glycosylation of proteins and the sorting of molecules destined for secretion or other organelles. While it produces lysosomes, it is not physically continuous with the nuclear envelope, distinguishing it from the rough endoplasmic reticulum in structural terms.

45. (A) $pH = pK_a$
According to the Henderson-Hasselbalch equation, the pH of a buffer depends on the pKa and the log of the ratio of base to acid. When these concentrations are equal, the ratio is one, and the logarithm of one is zero. Consequently, the pH becomes exactly equal to the pKa.

46. (A) Both A and R are true and R is the correct explanation of A
Red blood cells placed in a hypotonic solution experience a net influx of water because the solute concentration is higher inside the cell than outside. This osmotic movement occurs across the semipermeable membrane to reach equilibrium. Because the animal cell lacks a rigid wall, the resulting internal pressure causes the membrane to stretch, often leading to cell swelling and eventual rupture.

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47. (D) BET isotherm
The Brunauer-Emmett-Teller or BET isotherm is a mathematical model used to describe the multilayer adsorption of gas molecules onto solid surfaces. Unlike the Langmuir model, which is restricted to single layers, the BET theory accounts for the formation of multiple layers of adsorbate. It is widely applied in material science to calculate the specific surface area of porous or finely divided solids.

48. (A) Change in solution volume per unit mass of added solute
The partial specific volume represents the volume increase of a solution when one gram of a particular solute is added, assuming the temperature and pressure remain constant. It is a critical parameter in the Svedberg equation used during ultracentrifugation to determine the molecular weight of macromolecules. This value reflects the displacement of solvent and the inherent density of the macromolecule itself.

49. (A) P-2, Q-1, R-4, S-3
Different transport mechanisms move molecules across membranes based on their properties. Simple diffusion involves non-polar molecules moving down their gradient. Facilitated diffusion requires specific carriers but no energy. Primary active transport directly hydrolyzes ATP to move ions against their gradient. Secondary active transport uses the energy from an existing ion gradient, often established by an ATPase, to drive the transport of other solutes.

50. (C) Unequal distribution of diffusible ions across the membrane
The Gibbs-Donnan effect describes the behavior of charged particles near a semipermeable membrane when non-diffusible ions, such as large proteins, are present on one side. To maintain electrical neutrality, the diffusible ions distribute themselves unequally. This results in a higher concentration of particles on the side containing the proteins, creating a transmembrane electrical potential and an osmotic pressure difference.

51. (A) Increased cholesterol content
Cholesterol acts as a bidirectional regulator of membrane fluidity in animal cells. At physiological temperatures, its rigid ring structure interferes with the movement of phospholipid fatty acid chains, thereby decreasing membrane fluidity and increasing stability. Conversely, at lower temperatures, it prevents the chains from packing too tightly, preventing solidification. Increasing cholesterol concentration at normal body temperature generally makes the membrane more rigid.

52. (A) I, II and IV
The rate of dialysis is influenced by physical parameters that govern diffusion across a membrane. Increasing the surface area of the membrane and the temperature of the system enhances the movement of solutes. A steeper concentration gradient also drives faster diffusion. In contrast, increasing membrane thickness or decreasing pore size would impede the process by creating greater resistance to the passage of molecules.

53. (D) Coagulation
Coagulation is the process where colloidal particles aggregate and settle out of the dispersion medium. This often occurs when electrolytes are added, as the ions neutralize the surface charges that normally keep the particles apart through electrostatic repulsion. Once the stabilizing charges are reduced, the particles can collide and stick together, eventually forming larger masses that can no longer remain suspended.

54. (A) Its density compared to water
Selecting a buffer for biochemical experiments involves several critical criteria, such as ensuring the pKa is near the target pH and checking for potential interference with metal ions or light absorbance. However, the density of the buffer relative to water is generally irrelevant to its chemical buffering function. Focus is typically placed on compatibility with the biological system and the specific assay requirements.

55. (A) Nuclei
During differential centrifugation, cellular components are separated based on their size and density by applying increasing centrifugal forces. Nuclei are the largest and densest organelles in the cell homogenate, causing them to sediment at relatively low speeds, such as six hundred times gravity. Subsequent steps at higher speeds are required to pellet smaller components like mitochondria, microsomes, and finally, individual proteins.

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56. (B) Unbalanced cohesive forces on surface molecules
Surface tension arises because molecules at the surface of a liquid experience different intermolecular forces than those in the bulk. While molecules inside are pulled equally in all directions by neighbors, surface molecules feel a net inward pull because there are no liquid molecules above them. This imbalance creates a contractive force that causes the liquid surface to behave like a stretched elastic membrane.

57. (A) Rayleigh scattering
Rayleigh scattering describes the elastic scattering of light by particles that are significantly smaller than the wavelength of the incident radiation. In this regime, the intensity of the scattered light is inversely proportional to the fourth power of the wavelength. This physical principle explains why the sky appears blue and is used in biophysics to characterize the size and properties of small macromolecules.

58. (A) Both A and R are true and R is the correct explanation of A
Proteins are highly effective biological buffers because they contain various amino acid residues with ionizable side chains. These groups can either donate or accept protons depending on the surrounding hydrogen ion concentration, thereby resisting changes in pH. Histidine, in particular, has a side chain pKa close to physiological pH, making it a crucial contributor to the buffering capacity of cellular proteins.

59. (C) Ribosomes
The rough endoplasmic reticulum is distinguished by the presence of numerous ribosomes attached to its cytosolic surface. These ribosomes give the membrane its characteristic "rough" appearance under an electron microscope. They are responsible for synthesizing proteins that are either destined for secretion, incorporation into the cell membrane, or delivery to specific organelles like lysosomes within the endomembrane system.

60. (A) II, III, IV, I
Isolating microsomes through differential centrifugation requires a sequential approach. First, the tissue must be homogenized to release cellular contents. Low-speed centrifugation at six hundred gravity removes nuclei and debris. The resulting supernatant is then centrifuged at fifteen thousand gravity to pellet mitochondria. Finally, the remaining supernatant is subjected to very high speeds, like one hundred thousand gravity, to isolate the microsomal fraction.

61. (A) Its capacity to reduce the electrostatic attraction between dissolved ions
The dielectric constant is a physical property that measures a solvent's ability to reduce the electrostatic force between two charged particles. Solvents with high dielectric constants, like water, significantly weaken the attraction between cations and anions. this allows ionic compounds to dissociate and remain in solution, which is fundamental for the solubility of salts and many polar biological molecules in living systems.

62. (A) Extensive hydrogen bonding networks
Water possesses unique biophysical properties due to the extensive network of hydrogen bonds formed between its polar molecules. Each water molecule can participate in up to four hydrogen bonds, creating strong cohesive forces. This internal structure accounts for the unusually high boiling point, surface tension, and specific heat of water, all of which are essential for maintaining stable environments in biological systems.

63. (B) CH_3COOH / H_3O^+
A conjugate acid-base pair consists of two species that differ by exactly one proton. Acetic acid is a weak acid, and its conjugate base is the acetate ion, not the hydronium ion. The other pairs listed correctly demonstrate this relationship, where the acid has one more hydrogen ion than its corresponding base. Mismatched pairs do not satisfy the fundamental Brønsted-Lowry definition.

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64. (A) P-2, Q-4, R-1, S-3
Cellular compartments host specific metabolic activities. Glycolysis occurs in the cytosol. The citric acid cycle takes place within the mitochondria to generate energy. The smooth endoplasmic reticulum is the primary site for lipid and steroid synthesis. Lysosomes contain various hydrolases dedicated to the degradation of complex macromolecules. This spatial organization ensures that biochemical pathways are efficiently regulated and isolated from conflicting reactions.

65. (A) Both hydrophilic and hydrophobic regions
Amphipathic molecules possess both a polar, water-attracting hydrophilic region and a non-polar, water-repelling hydrophobic region. This dual nature is fundamental to the formation of biological membranes, where phospholipids arrange themselves into bilayers. The hydrophobic tails cluster together away from water, while the hydrophilic heads face the aqueous environment, creating a stable barrier that defines the boundaries of cells and organelles.

66. (C) Tight junctions
Tight junctions are specialized intercellular connections that form a nearly impermeable seal between adjacent epithelial cells. By fusing the outer leaflets of the plasma membranes, they prevent the leakage of extracellular fluid and solutes across the epithelial layer. This barrier function is crucial in organs like the intestines and kidneys, where selective transport and the maintenance of distinct environments are necessary.

67. (B) Acetic acid
Acetic acid is classified as a weak acid because it does not completely dissociate into ions when dissolved in water. In contrast, hydrochloric, sulfuric, and nitric acids are strong acids that ionize fully. In biological systems, weak acids like acetic acid and its derivatives are important metabolites and serve as components of buffer systems that help maintain stable hydrogen ion concentrations.

68. (C) II and III
The Gibbs-Donnan equilibrium involves the behavior of diffusible ions in the presence of non-diffusible species like proteins. It occurs across a semipermeable membrane that is not completely permeable to everything. At equilibrium, the product of the concentrations of the diffusible cation and anion on one side equals the product on the other side, resulting in an unequal distribution of ions.

69. (B) The shape and size of the macromolecule
The sedimentation rate of a macromolecule in an ultracentrifuge depends on its physical characteristics. Larger and denser molecules sediment faster, while the overall shape affects the frictional resistance encountered in the solvent. A compact, spherical molecule will move more quickly than an elongated one of the same mass. These factors, combined with solvent properties, determine the sedimentation coefficient of the macromolecule.

70. (A) Viscosity decreases
For most liquids, including biological fluids like blood plasma, viscosity decreases as the temperature rises. This occurs because increased thermal energy allows molecules to overcome the intermolecular forces that resist flow, making the liquid more fluid. This relationship is physiologically significant as changes in body temperature can influence blood flow dynamics and the work required by the heart to circulate blood.

71. (C) Thickness of the membrane
According to Fick's first law, the rate of diffusion is inversely proportional to the distance over which it occurs, which corresponds to the thickness of the membrane. As the barrier becomes thicker, the time required for a molecule to traverse it increases, thereby reducing the overall diffusion rate. Conversely, rates increase with larger surface areas, higher temperatures, and steeper concentration gradients.

72. (A) Singer-Nicolson fluid mosaic model
The Singer-Nicolson fluid mosaic model describes the cell membrane as a dynamic, two-dimensional liquid. In this model, the phospholipid bilayer provides a fluid matrix in which various proteins are embedded and can move laterally. This fluidity is essential for membrane functions such as cell signaling, transport, and the ability of the membrane to repair itself and change shape during cellular processes.

73. (D) Mitochondria
The endomembrane system includes a group of organelles that are either directly continuous or connected by vesicle transport, such as the endoplasmic reticulum, Golgi apparatus, and lysosomes. Mitochondria are excluded from this system because they have a double membrane, their own DNA, and operate largely independently. They likely originated from an ancient endosymbiotic event rather than the internal membrane budding process.

74. (A) Sucrose or Ficoll
Density-gradient centrifugation requires a solute that can form a stable, predictable gradient without damaging cellular components. Sucrose

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and Ficoll are commonly used because they are chemically inert and can be prepared at various concentrations to cover the density range of organelles. As the centrifuge spins, particles migrate through this gradient until they reach a zone where their density matches the medium.

75. (C) Diffusion occurs from regions of lower to higher concentration
Fick's first law of diffusion states that the net movement of molecules always occurs from an area of higher concentration to one of lower concentration, following the gradient. Stating that diffusion happens in the opposite direction is incorrect, as that would require the input of energy, defining active transport rather than the passive process described by Fick's fundamental laws.

76. (A) Both A and R are true and R is the correct explanation of A
Dialysis relies on a semipermeable membrane with specific pore sizes to separate solutes. While small molecules like salts can pass freely through these pores, large proteins are typically much larger than the pore diameter. Consequently, the membrane acts as a physical barrier that retains the proteins while allowing contaminants to diffuse away, making it an effective purification but ineffective removal tool.

77. (A) $a = \gamma \times c$
The activity of an ion, which represents its effective concentration, is calculated by multiplying its actual molar concentration by the activity coefficient. This coefficient accounts for the non-ideal behavior of ions caused by electrostatic interactions in the solution. In perfectly ideal or extremely dilute solutions, the coefficient approaches one, making the activity and concentration numerically equal for practical calculations.

78. (B) Adsorption on heterogeneous surfaces
The Freundlich isotherm is an empirical model used to describe the adsorption of solutes from a liquid or gas onto a solid surface. Unlike the Langmuir model, it assumes that the surface is heterogeneous with sites of varying affinities and that adsorption is not limited to a single layer. It is particularly useful for describing adsorption processes in complex environmental and biological systems.

79. (A) P-4, Q-3, R-1, S-2
Various biophysical terms define specific phenomena. The Svedberg unit measures sedimentation velocity in a centrifuge. Dialysis involves separation based on diffusion through a membrane barrier. Osmosis specifically refers to the movement of solvent molecules across a semipermeable membrane. Electrophoresis describes the migration of charged particles under the influence of an electric field, which is essential for analyzing proteins and nucleic acids.

80. (B) Isoelectric focusing
Isoelectric focusing is a high-resolution separation technique that utilizes a pH gradient established within a gel. Proteins migrate through this gradient under an electric field until they reach the specific pH where their net charge is zero, known as the isoelectric point. At this position, they stop moving, allowing for the separation of proteins that might have similar sizes but different charges.

81. (C) Potassium
Potassium is the most abundant intracellular cation in animal cells. It plays a fundamental role in maintaining cellular osmolarity, regulating cell volume, and establishing the resting membrane potential. The high internal concentration of potassium is maintained by the active transport of the sodium-potassium ATPase pump, which continuously moves potassium into the cell against its electrochemical gradient to support various functions.

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82. (A) II, III, IV, I
Determining a protein's subcellular location involves a systematic process. First, the tissue is homogenized to break open the cells. The resulting homogenate is then fractionated using differential centrifugation at increasing speeds. Once the different organelle fractions are isolated, they are analyzed using Western blotting with specific marker antibodies to identify which compartment contains the protein of interest for study.

83. (A) pH is exactly equal to pKa
Buffer capacity is the ability of a solution to resist changes in pH when an acid or base is added. This capacity is mathematically and functionally maximized when the pH of the solution is exactly equal to the pKa of the weak acid. At this specific point, the concentrations

of the acid and its conjugate base are equal, providing optimal resistance to changes.

84. (A) Non-Newtonian flow behavior
Certain biological fluids, such as synovial fluid in joints, exhibit non-Newtonian flow behavior. Specifically, they show shear-thinning properties, where their viscosity decreases as the rate of shear increases. This allows the fluid to act as a highly effective lubricant, becoming thinner and easier to move during rapid joint activity while remaining more viscous and protective when the joint is at rest.

85. (A) It can form a maximum of only two hydrogen bonds per molecule
A single water molecule can actually form up to four hydrogen bonds because it has two hydrogen atoms to donate and two lone pairs on the oxygen atom to accept bonds. The statement claiming a maximum of only two bonds is incorrect. Water's ability to form extensive four-bond networks is what gives it high cohesion, surface tension, and a high heat of vaporization.

86. (C) The ratio of conjugate base to weak acid
To calculate the pH of a buffer solution using the Henderson-Hasselbalch equation, one must know the pKa of the weak acid and the concentrations of both the conjugate base and the acid. Specifically, the log of the ratio of these two components is added to the pKa. This relationship shows how the relative amounts of the buffer species determine the final pH.

87. (B) I, III and IV
Lysosomes are acidic organelles containing a wide array of hydrolytic enzymes for intracellular digestion and autophagy. They maintain an internal environment with a low pH, typically around five, using proton pumps. Acid phosphatase serves as a reliable marker enzyme for identifying these organelles during cell fractionation. Stating their internal pH is highly basic is incorrect, as their function requires high acidity.

88. (A) Both A and R are true and R is the correct explanation of A
Small, uncharged molecules like oxygen and carbon dioxide can easily cross the plasma membrane through simple diffusion. Their high lipid solubility allows them to dissolve into and pass through the hydrophobic core of the phospholipid bilayer without the need for transport proteins. This property is essential for the rapid exchange of respiratory gases between cells and their surrounding environment or blood.

89. (B) Plasma membrane
In prokaryotic cells, oxidative phosphorylation occurs on the plasma membrane because they lack mitochondria. The electron transport chain and ATP synthase are embedded in the plasma membrane, where electrons are transferred to generate a proton gradient. This proton motive force drives ATP synthesis by chemiosmosis, making the plasma membrane the primary site of aerobic energy production in bacteria.

90. (C) Partial double bond character
The peptide bond in proteins exhibits a partial double bond character due to resonance between the carbonyl oxygen and the amide nitrogen. This character makes the bond rigid and planar, effectively preventing free rotation around the carbon-nitrogen axis. This restriction is a fundamental biophysical property that dictates the possible conformations of the polypeptide chain and influences the overall folding and structure.

91. (A) P-3, Q-1, R-2, S-4
Centrifugation techniques are tailored for specific separation needs. Differential centrifugation uses sequential pelleting at increasing speeds to separate organelles by size. Rate-zonal centrifugation separates particles based on size and mass over a specific time within a gradient. Isopycnic centrifugation relies on buoyant density equivalence. Analytical ultracentrifugation involves continuous monitoring of sedimentation boundaries to determine the precise physical properties and molecular weights of macromolecules.

92. (A) $10^{\{-13\}}$ seconds
The Svedberg unit, denoted by the symbol S, is a non-metric unit for sedimentation coefficients. It is defined as exactly ten to the power of negative thirteen seconds. This unit quantifies how fast a particle travels in a centrifugal field relative to the acceleration applied. It is named after the Nobel Prize-winning chemist Theodor Svedberg, who developed the first analytical ultracentrifuge.

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93. (C) Increases Km, leaves Vmax unchanged
A competitive inhibitor competes with the substrate for the same active site on an enzyme. This increases the apparent Km, meaning a higher substrate concentration is required to reach half the maximum velocity. However, if the substrate concentration is sufficiently high, it can outcompete the inhibitor, allowing the enzyme to still reach its original maximum velocity, leaving the Vmax unchanged.

94. (C) One gram of substance by one degree Celsius
Specific heat capacity is a physical property defined as the amount of heat energy required to raise the temperature of one gram of a substance by one degree Celsius. Water has an exceptionally high specific heat, which allows it to absorb large amounts of heat with minimal temperature change. This property is vital for temperature regulation in living organisms and aquatic environments.

95. (B) Use of sphingosine instead of glycerol
The fundamental structural difference between sphingolipids and phosphoglycerides lies in the backbone molecule used. Phosphoglycerides are built upon a glycerol backbone, whereas sphingolipids utilize sphingosine, a long-chain amino alcohol. This difference leads to distinct chemical properties and biological functions, although both types are amphipathic and serve as essential components of the cell membranes in eukaryotic organisms.

96. (A) I, III and IV
Active transport is an energy-dependent process that moves solutes against their concentration gradient. It requires specific carrier proteins that exhibit saturation kinetics, similar to enzyme-substrate interactions. Because it depends on metabolic energy, often in the form of ATP, it is sensitive to metabolic poisons like cyanide that disrupt ATP production. It does not solely rely on kinetic energy or move down gradients.

97. (A) Both A and R are true and R is the correct explanation of A
Peripheral membrane proteins are associated with the lipid bilayer surface through weak electrostatic and hydrogen bonds rather than being embedded within it. Because these interactions are relatively superficial, they can be disrupted by changing the ionic strength of the environment. Washing the membrane with high-salt solutions effectively neutralizes these charges, allowing the peripheral proteins to be removed without destroying the membrane.

98. (A) Serine
Serine is an amino acid characterized by a polar hydroxyl group in its side chain. At physiological pH, this side chain remains uncharged, unlike basic amino acids like lysine or acidic ones like glutamate. Its polarity allows it to participate in hydrogen bonding and makes it hydrophilic, which influences the folding and solubility of proteins in the aqueous environment of the cell.

99. (B) Flippases and floppases
The plasma membrane maintains an asymmetrical distribution of lipids between the inner and outer leaflets. This organization is actively managed by specialized enzymes called flippases and floppases, which use ATP to move specific phospholipids from one side to the other. Additionally, scramblases can move lipids non-selectively. This asymmetry is crucial for cell signaling, membrane curvature, and various other cellular functions.

100. (A) There must be at least one impermeable charged species on one side
To establish a Gibbs-Donnan equilibrium, a semipermeable membrane must separate two compartments where at least one charged species, such as a large protein, cannot cross. The presence of this trapped ion forces the diffusible ions to distribute themselves unequally to maintain electrical neutrality. This leads to differences in total ion concentration and osmotic pressure between the two sides of the membrane.

101. (B) Thixotropy
Thixotropy is a reversible property observed in certain colloidal gels where they become less viscous and turn into a liquid sol when subjected to mechanical stress, such as shaking or stirring. Once the agitation stops and the system is allowed to rest, the sol reverts to its original gel state. This behavior is important in various biological fluids and industrial applications.

102. (B) Sonication
Sonication is a homogenization technique that uses high-frequency sound waves to disrupt cell membranes and walls. The sound waves create microscopic vacuum bubbles in the liquid, a process called cavitation, which implode and

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generate intense local shock waves. These forces are powerful enough to shear cells and break down complex structures, allowing for the extraction of intracellular components for further biochemical analysis.

103. (A) III, II, I, IV
The permeability of a cell membrane depends on the chemical nature of the molecules. Small ions like sodium have the lowest permeability because they are charged and require transport proteins. Larger polar molecules like glucose come next, followed by small polar but uncharged molecules like water. Small nonpolar gases like oxygen pass most easily through the hydrophobic lipid bilayer by simple diffusion.

104. (B) High concentration of mitochondria
Mature mammalian red blood cells are highly specialized for oxygen transport and lack several typical organelles, including a nucleus and mitochondria. By eliminating mitochondria, these cells avoid consuming the oxygen they are designed to carry. Consequently, they rely entirely on anaerobic glycolysis for their energy needs. The absence of mitochondria is a key feature that distinguishes them from other eukaryotic cells.

105. (A) P-2, Q-1, R-4, S-3
Biophysical techniques serve various analytical purposes. Ultrafiltration uses pressure to concentrate macromolecules by removing solvent. Dialysis is primarily used for desalting solutions through passive diffusion. Light scattering provides data on molecular mass and the radius of gyration. Ultracentrifugation allows for the determination of molecular weight based on how particles sediment in a high-speed centrifugal field, providing deep insights into macromolecular properties.

106. (A) 7.35 - 7.45
The normal physiological pH of mammalian arterial blood is strictly maintained within the narrow range of seven point three five to seven point four five. This precise balance is essential for the proper functioning of enzymes and physiological processes. Deviations below this range indicate acidosis, while values above it represent alkalosis, both of which can lead to severe clinical complications if not corrected.

107. (C) Facilitated diffusion
Facilitated diffusion is a passive transport mechanism that allows polar or large molecules to cross the plasma membrane down their concentration gradient. It requires specific carrier proteins or channels to bypass the hydrophobic lipid bilayer but does not involve the expenditure of metabolic energy. Unlike simple diffusion, this process exhibits saturation kinetics, meaning the transport rate becomes constant at high solute concentrations.

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108. (A) Both A and R are true and R is the correct explanation of A
In extremely dilute solutions, the activity coefficient of an ion approaches unity because the ions are spaced so far apart that their mutual electrostatic interactions become negligible. Under these conditions, the solution behaves ideally, and the effective concentration or activity becomes essentially equal to the measured molar concentration. This principle is fundamental for applying simplified thermodynamic equations to dilute biological and chemical systems.

109. (A) I, II, III, IV
Protein structure is organized hierarchically. It begins with the primary structure, which is the specific amino acid sequence. Secondary structures, such as alpha helices, form through local hydrogen bonding. The tertiary structure arises from the overall folding of the polypeptide chain into a three-dimensional shape. Finally, quaternary structure involves the assembly of multiple polypeptide subunits into a functional multimeric complex.

110. (B) They are excellent biological buffers at physiological pH
Strong electrolytes, such as sodium chloride or hydrochloric acid, dissociate completely in solution and do not possess the ability to resist pH changes. Effective biological buffers must be weak acids or bases that exist in an equilibrium between protonated and deprotonated forms. While strong electrolytes contribute to ionic strength and osmotic pressure, they cannot function as buffers near physiological hydrogen ion levels.

111. (C) Hypertonic
Plasmolysis is the process in which a cell, particularly a plant cell, loses water and its protoplast shrinks away from the cell wall. This

occurs when the cell is placed in a hypertonic solution, where the external solute concentration is higher than that of the cytoplasm. The resulting osmotic pressure drives water out of the cell, leading to a loss of turgor pressure.

112. (A) I, III and IV
Mitochondria are double-membrane organelles responsible for most of the ATP production through oxidative phosphorylation. They contain their own circular DNA and ribosomes, which supports the theory of their endosymbiotic origin. The inner membrane is highly folded into cristae to increase the surface area for energy-producing reactions. They are not considered part of the endomembrane system, which includes the ER and Golgi.

113. (A) Predominance of deprotonated carboxyl groups
At physiological pH, most proteins carry a net negative charge, resulting in a negative zeta potential in colloidal dispersions. This is primarily due to the deprotonation of carboxyl groups on acidic amino acid side chains, such as glutamate and aspartate, which lose a proton and become negatively charged. This negative surface charge is crucial for keeping proteins soluble and preventing their unwanted aggregation.

114. (A) Latent heat of vaporization
The latent heat of vaporization is the amount of energy required to transform a given quantity of a substance from a liquid into a gas without changing its temperature. For water, this value is exceptionally high due to the need to break numerous hydrogen bonds. This biophysical property allows animals to lose significant amounts of heat through minimal water loss during evaporation.

115. (B) Within ± 1 pH unit of the desired physiological pH
A buffer system is most effective at resisting pH changes when the target pH of the solution is within one unit of the buffer's pKa. In this range, both the weak acid and its conjugate base are present in significant amounts to neutralize added protons or hydroxyl ions. Beyond this range, the concentration of one component becomes too low to provide protection.

116. (A) P-2, Q-1, R-3, S-4
Lipids have specific cellular locations and functions. Cardiolipin is unique to the inner mitochondrial membrane. Glycolipids are found on the outer leaflet of the plasma membrane for cell recognition. Cholesterol is a key regulator of membrane fluidity. Phosphatidylinositol plays a critical role in cell signaling and membrane trafficking. These distributions are vital for maintaining the structural and functional identity of cellular compartments.

117. (A) $GLUT_1$ mediated facilitated diffusion
Glucose enters erythrocytes through facilitated diffusion using the $GLUT_1$ carrier protein. This transport is passive, moving glucose down its concentration gradient without the use of ATP. The $GLUT_1$ transporter undergoes a conformational change upon binding glucose, allowing the molecule to pass through the membrane. This mechanism ensures a steady supply of glucose for the cell's energy production via anaerobic glycolysis.

118. (C) Diffusion occurs from regions of lower to higher concentration
Passive diffusion is governed by the concentration gradient, where molecules move spontaneously from areas of high concentration to areas of low concentration. Any claim that diffusion occurs in the opposite direction is physically incorrect, as moving substances from lower to higher concentration requires an input of external energy, which characterizes active transport rather than the passive process defined by Fick's laws.

119. (D) III and IV
Eukaryotic ribosomes can exist as free complexes in the cytosol or attached to the endoplasmic reticulum. Those bound to the ER are responsible for synthesizing proteins destined for the endomembrane system or secretion. While they consist of forty S and sixty S subunits, their combined sedimentation coefficient is eighty S, not one hundred S, due to the non-additive nature of Svedberg units.

120. (A) Both A and R are true and R is the correct explanation of A
Unlike animal cells, plant cells are encased in a rigid cell wall composed of cellulose. When placed in a hypotonic environment like distilled water, water enters the cell by osmosis, causing

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the protoplast to expand. The cell wall exerts a counteracting pressure, known as turgor pressure, which prevents further water entry and keeps the cell from bursting, providing structural support.

121. (A) It can alter the apparent pKa due to changes in activity coefficients
An increase in the ionic strength of a solution influences the electrostatic environment surrounding ionizable groups. This change affects the activity coefficients of the weak acid and its conjugate base, leading to a shift in the apparent pKa. Consequently, the dissociation equilibrium is altered, which can significantly impact the buffering capacity and pH of biological fluids containing various dissolved salts and minerals.

122. (A) Pinocytosis
Pinocytosis, often referred to as "cell drinking," is a form of endocytosis where the cell engulfs droplets of extracellular fluid into small vesicles. This process is non-specific, allowing the cell to take up dissolved solutes along with the fluid. It is a continuous activity in many eukaryotic cells, contributing to the regulation of cell volume and the internal environment by recycling components.

123. (C) Lysosomes
Acid phosphatase is a hydrolase enzyme that operates optimally in acidic environments and is sequestered within lysosomes. In subcellular fractionation, measuring the activity of this enzyme allows researchers to identify the lysosomal fraction and assess the purity of the isolated organelles. Its presence is a definitive biochemical signature for these digestive compartments, distinguishing them from other organelles like mitochondria or nuclei.

124. (A) II, III, I, IV
The Henderson-Hasselbalch equation is derived starting from the equilibrium constant expression for a weak acid. The equation is solved for the hydrogen ion concentration, and then the negative logarithm is taken for both sides of the relationship. Finally, pH and pKa are substituted for their respective log terms to arrive at the familiar formula used to calculate buffer pH and component ratios.

125. (A) $[Na^+]_A \times [Cl^-]_A = [Na^+]_B \times [Cl^-]_B$
The Donnan equilibrium equation states that at equilibrium, the product of the concentrations of the diffusible cation and anion on one side of a semipermeable membrane must equal the product on the other side. This relationship arises from the thermodynamic requirement that the chemical potential of the diffusible electrolyte be equal in both compartments, despite the presence of non-diffusible charged species.

126. (B) Gel filtration chromatography
Gel filtration chromatography, also known as size-exclusion chromatography, separates molecules based exclusively on their size and hydrodynamic volume. The stationary phase consists of porous beads that allow smaller molecules to enter, slowing their progress through the column. Larger molecules are excluded from the pores and travel only through the space between beads, resulting in their earlier elution compared to the smaller ones.

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127. (D) Lysosome
Lysosomes require a highly acidic internal environment, typically around pH five, to activate their hydrolytic enzymes. This acidity is maintained by specialized vacuolar-type proton pumps located in the lysosomal membrane, which actively transport hydrogen ions from the cytosol into the organelle using energy from ATP hydrolysis. This compartmentalization protects the rest of the cell from accidental degradation by these powerful digestive enzymes.

128. (A) It maintains high intracellular sodium levels
The Na^+/K^+ ATPase pump is responsible for maintaining low intracellular sodium levels and high intracellular potassium levels by moving these ions against their respective gradients. It is an electrogenic pump that consumes ATP to drive three sodium ions out for every two potassium ions it brings in. Stating that it maintains high intracellular sodium is incorrect, as its primary purpose is the opposite.

129. (A) P-1, Q-2, R-3, S-4
Surface chemistry involves distinct processes. Adsorption is the accumulation of species on a surface, while absorption involves penetration into the bulk phase. Desorption is the removal of adsorbed molecules from a surface. Chemisorption specifically refers to adsorption where strong chemical bonds are formed between the adsorbate and the surface, distinguished

from the weaker physical interactions found in physisorption during typical surface events.

130. (B) Maximization of entropy of the water molecules
The hydrophobic effect is driven by the thermodynamic tendency of water to maximize its entropy. When nonpolar molecules are present, water forms highly ordered clathrate cages around them, which is entropically unfavorable. By clustering the nonpolar molecules together, the total surface area exposed to water is reduced, releasing these water molecules back into the bulk phase and increasing the overall disorder of the system.

131. (A) Carbon dioxide
The lungs play a vital role in acid-base balance by regulating the elimination of carbon dioxide, which acts as a volatile acid equivalent. When carbon dioxide dissolves in blood, it forms carbonic acid, which then dissociates into protons and bicarbonate. By increasing or decreasing the rate of ventilation, the lungs can rapidly adjust the concentration of dissolved gas, thereby influencing the blood pH level.

132. (A) I, II and IV
Peroxisomes are single-membrane organelles that contain catalase and other oxidases. They are essential for breaking down hydrogen peroxide and conducting the beta-oxidation of very long-chain fatty acids. Stating that they possess a double membrane is incorrect, as they are part of the single-membrane organelle group. Their metabolic functions are critical for detoxifying the cell and maintaining lipid balance through oxidative reactions.

133. (A) Both A and R are true and R is the correct explanation of A
The inner mitochondrial membrane is exceptionally impermeable to ions and polar molecules, a property maintained by its high protein content and unique lipids like cardiolipin. This barrier is essential for the establishment of a proton gradient during the electron transport chain. The resulting proton motive force drives ATP synthesis through ATP synthase, making the membrane's impermeability a fundamental requirement for cellular respiration.

134. (A) Syneresis
Syneresis is the phenomenon where a gel contracts over time, causing the liquid dispersion medium to be squeezed out and collect on the surface. This occurs as the particles within the gel framework aggregate more closely, reducing the internal volume available for the solvent. It is commonly observed in biological systems and various industrial products, representing a form of instability or aging in gels.

135. (D) Osmosis
Osmosis is the spontaneous net movement of solvent molecules, typically water, across a semipermeable membrane from a region of lower solute concentration to one of higher solute concentration. This passive process continues until the chemical potential of the solvent is equalized on both sides of the membrane. It is the primary mechanism by which cells regulate their internal water content and volume.

136. (A) Activity coefficient
The activity coefficient is a numerical factor that represents the degree of non-ideality in a solution. It relates the activity, or effective concentration, of an ion to its actual molar concentration. In biological fluids where ion concentrations are significant, electrostatic interactions between particles cause deviations from ideal behavior, making the activity coefficient a necessary parameter for accurate thermodynamic and electrochemical calculations.

137. (B) It can generate localized heat, potentially denaturing proteins
Mechanical homogenization is an effective way to disrupt tough tissues, but it has the disadvantage of generating significant localized heat through friction. This increase in temperature can lead to the denaturation of sensitive proteins and enzymes if the sample is not kept cold during the procedure. In contrast, osmotic lysis is a milder process that does not involve high-speed mechanical shearing or heat generation.

138. (B) Steroid hormones
The smooth endoplasmic reticulum lacks ribosomes and is specialized for several metabolic functions, including the synthesis of lipids and steroid hormones. Cells that produce these hormones, such as those in the adrenal cortex or gonads, possess an extensive network of smooth ER. This organelle also plays a key role in

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calcium storage and the detoxification of various drugs and harmful metabolic byproducts.

139. (A) I, II, III
Biological interactions vary greatly in strength. Van der Waals forces are the weakest, involving transient dipoles between molecules. Hydrogen bonds are stronger, resulting from the attraction between a hydrogen atom and an electronegative atom like oxygen. Covalent bonds are the strongest, involving the sharing of electron pairs between atoms. This hierarchy of bond energies is fundamental to the structure and stability of biological macromolecules.

140. (A) $\pi = MRT$
The osmotic pressure of a dilute non-electrolyte solution is calculated using a formula similar to the ideal gas law. It states that the pressure is equal to the molar concentration of the solute multiplied by the ideal gas constant and the absolute temperature. This equation demonstrates that osmotic pressure depends solely on the number of particles in solution, regardless of their chemical identity.

141. (A) P-1, Q-2, R-3, S-4
Subcellular compartments are identified using specific marker enzymes. DNA polymerase is characteristic of the nucleus. Cytochrome c oxidase is a vital component of the mitochondrial electron transport chain. The sodium-potassium ATPase is an integral protein found in the plasma membrane. Lactate dehydrogenase is a soluble enzyme located in the cytosol. These markers are essential for verifying the purity of organelle fractions during research.

142. (A) The membrane is a rigid, static structure
The fluid mosaic model emphasizes that the plasma membrane is a dynamic and flexible structure, not a rigid one. Lipids and proteins within the membrane can diffuse laterally, providing fluidity that is essential for cell function. Stating that the membrane is rigid and static is incorrect, as this would prevent essential processes like signaling, transport, and the movement of integral membrane proteins.

143. (A) Hemoglobin buffer
Hemoglobin serves as the primary intracellular buffer within red blood cells. It possesses numerous ionizable histidine residues that can bind or release protons in response to pH changes. This buffering capacity is crucial for neutralizing the hydrogen ions produced when carbon dioxide is converted into bicarbonate, ensuring that the internal environment of the erythrocyte remains stable during gas transport throughout the circulatory system.

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144. (A) Higher in the intracellular fluid than outside the cell
In typical mammalian cells, the concentration of potassium ions is significantly higher inside the cell compared to the surrounding extracellular fluid. This concentration gradient is actively maintained by the sodium-potassium ATPase pump. The resulting imbalance is fundamental for establishing the resting membrane potential and is critical for various physiological processes, including nerve impulse conduction and muscle contraction in living organisms.

145. (A) I, II and III
Light scattering in macromolecular solutions arises from local fluctuations in refractive index. It is a powerful analytical tool used to determine the weight-average molecular weight and size of particles. According to Rayleigh's theory, the intensity of the scattered light is inversely proportional to the fourth power of the wavelength. It occurs in transparent or translucent solutions, not just in completely opaque ones.

146. (A) Both A and R are true and R is the correct explanation of A
Facilitated diffusion is a passive transport process that relies on a concentration gradient to move molecules across a membrane. Because it does not utilize an external energy source like ATP hydrolysis, it cannot move solutes against their gradient from a lower to a higher concentration. The process is limited by the availability of carrier proteins and eventually reaches equilibrium between both sides.

147. (D) High flammability
Water is a chemically stable molecule and is not flammable, which is a property completely irrelevant to its biological functions. Its critical physiological roles are instead derived from its high dielectric constant, high surface tension, and high latent heat of vaporization. These characteristics support its function as a solvent, a temperature regulator, and a structural medium for all living cells and biological processes.

148. (A) Hydration volume
The hydration volume refers to the volume of solvent that is tightly associated with a macromolecule in solution. Biological molecules like proteins and nucleic acids attract water molecules to their polar surfaces, creating a hydration shell that moves with the macromolecule. This bound water influences the physical properties, stability, and hydrodynamic behavior of the molecule, distinguishing it from the surrounding bulk solvent.

149. (A) A proton
The Brønsted-Lowry theory defines acid-base reactions as the transfer of a proton from one species to another. An acid acts as the proton donor, while a base acts as the proton acceptor. this model emphasizes the reciprocal relationship between conjugate acid-base pairs and provides a comprehensive framework for understanding chemical equilibria in both aqueous and non-aqueous environments within biological systems.

150. (B) Golgi apparatus
The Golgi apparatus is a specialized organelle responsible for the modification, sorting, and packaging of proteins. As proteins move through its cisternae, they undergo various chemical modifications, such as the addition of carbohydrate groups. The Golgi then directs these molecules into specific vesicles for transport to their final destinations, including the cell surface for secretion or to other organelles like lysosomes.

151. (A) IV, III, II, I
The pH scale is inversely related to the hydrogen ion concentration, where lower pH values indicate higher acidity. Therefore, a pH of nine represents the lowest hydrogen ion concentration in this series, followed by pH seven, then pH four. A pH of two represents the highest hydrogen ion concentration. Arranging them from lowest to highest concentration results in the sequence nine, seven, four, two.

152. (A) P-2, Q-3, R-1
Active transport mechanisms are classified based on the number and direction of the molecules moved. Uniport involves the transport of a single species in one direction. Symport moves two different species simultaneously in the same direction. Antiport involves the movement of two species in opposite directions across the membrane. These mechanisms are essential for maintaining ion gradients and transporting nutrients into cells against their gradients.

153. (B) 4.76
In a buffer system prepared with equimolar concentrations of a weak acid and its conjugate base, the ratio of base to acid is one. According to the Henderson-Hasselbalch equation, the log of one is zero, which means the pH of the solution is exactly equal to the pKa of the weak acid. For an acetic acid buffer, this results in a pH of four point seven six.

154. (B) Nucleolus - Lipid synthesis
The nucleolus is the site of ribosomal RNA synthesis and ribosome assembly, not lipid synthesis. Lipid synthesis primarily occurs in the smooth endoplasmic reticulum. The other statements correctly link ribosomes to protein synthesis, lysosomes to intracellular digestion, and mitochondria to cellular respiration. Misidentifying the nucleolus ignores its critical role in genetic expression and the production of the cell's translation machinery.

155. (A) Electrophoresis
Electrophoresis is the biophysical process that governs the movement of charged colloidal particles through a medium when an external electric field is applied. Particles migrate toward the electrode with the opposite charge at a rate determined by their size, shape, and net surface charge. This principle is fundamental to many analytical techniques used to separate and identify proteins and nucleic acids in research.

156. (B) I and III
The Gibbs-Donnan equilibrium contributes to the resting membrane potential and results in a higher internal osmotic pressure due to trapped proteins. However, it is a passive equilibrium process that does not require energy from ATP to be established. Active transport, such as the Na^+/K^+ pump, actually works to counteract the osmotic swelling that would otherwise result from the Gibbs-Donnan effect in animal cells.

157. (A) Both A and R are true and R is the correct explanation of A
Surfactants are amphipathic molecules that migrate to the air-water interface, where they align themselves to reduce the contact between water and air. By intercalating between water

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molecules, they disrupt the strong hydrogen bonding network that creates surface tension. This disruption leads to a significant decrease in the surface tension of the water, which is essential for various physiological and industrial processes.

158. (A) Synovial fluid
Synovial fluid is a biological lubricant found in the cavities of synovial joints. It exhibits non-Newtonian, shear-thinning behavior, meaning its viscosity decreases under mechanical stress. This property is vital for protecting joint surfaces during movement. At rest, the fluid is more viscous, but as the joint moves faster, it becomes thinner, facilitating smooth motion and reducing friction between the cartilage surfaces.

159. (C) Solute particles are smaller than the wavelength of visible light and do not scatter it significantly
The Tyndall effect is absent in true solutions because the solute particles, such as individual ions or small molecules, are much smaller than the wavelength of visible light. Consequently, they do not scatter the light rays effectively. In contrast, colloidal particles are large enough to interact with the light waves, making the path of a light beam visible as it passes through the dispersion.

160. (A) Gel filtration chromatography (Size exclusion)
Gel filtration chromatography is the most efficient method for separating molecules based solely on their size differences without using electric fields or centrifugal forces. The porous matrix allows smaller ten kilodalton molecules to enter the beads, delaying their elution, while the larger one hundred kilodalton molecules are excluded and move faster through the column. This size-based separation is gentle and highly effective for proteins.

161. (A) Fragments of endoplasmic reticulum and plasma membrane
In subcellular fractionation, the microsomal fraction consists of small vesicles formed from the fragmentation of the endoplasmic reticulum and the plasma membrane during tissue homogenization. These vesicles pellet only at very high centrifugal speeds, typically around one hundred thousand times gravity. This fraction is widely used in biochemical studies to investigate protein synthesis, lipid metabolism, and the activity of membrane-bound enzymes.

162. (A) P-2, Q-1, R-3, S-4
Fundamental constants and equations underpin biological processes. The dielectric constant influences the dissolving capacity of water for ions. The Henderson-Hasselbalch equation is essential for buffer preparation and pH estimation. The van 't Hoff equation allows for the calculation of osmotic pressure in solutions. Fick's first law describes the rate of passive diffusion, providing a quantitative framework for understanding how molecules move across membranes.

163. (B) Carbonic acid (H_2CO_3) / dissolved CO_2
When a strong acid is added to the bicarbonate buffer system, the excess protons react with bicarbonate ions to form carbonic acid. This carbonic acid then quickly dissociates into water and carbon dioxide. This mechanism allows the body to neutralize acid challenges by converting them into carbon dioxide, which can be easily eliminated by the lungs, effectively preventing significant changes in blood pH.

164. (B) Facilitated diffusion exhibits saturation kinetics at high substrate concentrations
Facilitated diffusion differs from simple diffusion because it relies on a finite number of specific transport proteins. As the concentration of the solute increases, the transport rate eventually reaches a maximum when all available carrier proteins are occupied. This results in saturation kinetics, a characteristic that is not observed in simple diffusion, where the rate continues to increase linearly with the concentration gradient.

165. (C) I, II and III
Tissue homogenization involves mincing the sample, suspending it in an isotonic buffer to prevent osmotic damage to organelles, and applying mechanical shear or acoustic disruption to break the cell membranes. Boiling the sample is not part of standard homogenization for fractionation, as it would denature the enzymes and proteins that researchers intend to isolate and study in their functional states.

166. (A) Both A and R are true and R is the correct explanation of A
Eukaryotic cells use membrane-bound organelles to compartmentalize metabolic pathways, which enhances efficiency and regulation.

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Each organelle maintains a unique internal environment, such as a specific pH or enzyme concentration, that is optimized for its particular biochemical reactions. This spatial separation prevents conflicting reactions from occurring simultaneously and allows for the concentrated storage of metabolites and enzymes needed for specific tasks.

167. (A) Potential difference between the medium and the stationary layer
The zeta potential is the electrical potential difference between the bulk dispersion medium and the stationary layer of fluid attached to the surface of a colloidal particle. It is a key indicator of colloidal stability, as a high zeta potential indicates strong electrostatic repulsion between particles, which prevents them from aggregating or coagulating. It reflects the net charge within the particle's slipping plane.

168. (A) 1×10^{-3}
The pH of a solution is defined as the negative base ten logarithm of the hydrogen ion concentration. Therefore, a pH value of three corresponds to a hydrogen ion concentration of ten to the power of negative three moles per liter. This logarithmic scale means that each unit change in pH represents a tenfold change in the concentration of hydrogen ions in the solution.

169. (B) To modulate membrane fluidity and stabilize the lipid bilayer
Cholesterol is a critical lipid component in animal cell membranes, where it inserts between phospholipids. Its primary role is to modulate membrane fluidity, preventing the membrane from becoming too fluid at high temperatures or too rigid at low temperatures. By stabilizing the lipid bilayer, cholesterol ensures that the membrane remains functional and maintains its integrity across a range of physiological conditions.

170. (A) $\Delta G^{\circ} = -RT\ln(Keq)$
The standard free energy change of a reaction is mathematically related to its equilibrium constant through a logarithmic relationship. Specifically, the standard free energy change equals the negative product of the ideal gas constant, the absolute temperature, and the natural logarithm of the equilibrium constant. this equation allows biochemists to predict the spontaneity and direction of metabolic reactions under standard biochemical conditions.

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171. (C) The heat of vaporization of water is exceptionally low
Water actually possesses an exceptionally high heat of vaporization, which is one of its most important biophysical properties. This high energy requirement to convert liquid water into gas allows organisms to dissipate large amounts of body heat through the evaporation of a small volume of sweat. Stating that the heat of vaporization is low is incorrect, as it would diminish water's efficiency as a coolant.

172. (A) P-2, Q-3, R-4, S-1
Subcellular fractionation employs various media and techniques. Isopycnic centrifugation often uses cesium chloride or Percoll to separate based on density. Differential centrifugation is conducted in a homogeneous isotonic buffer. Cell lysis is frequently achieved using a hypotonic buffer to induce osmotic swelling and rupture. Rate-zonal centrifugation typically utilizes a continuous sucrose density gradient to separate particles based on their size and sedimentation velocity.

173. (A) Calculating molecular weight from ultracentrifugation data
The partial specific volume is a necessary parameter for calculating the molecular weight of macromolecules using the Svedberg equation. It accounts for the volume of solvent displaced by the macromolecule, which influences its buoyancy and sedimentation behavior in a centrifugal field. Accurate molecular weight determination requires knowing this value, along with the sedimentation coefficient, diffusion coefficient, and solvent density in the system.

174. (A) Secondary active transport
Secondary active transport involves the movement of one solute against its concentration gradient, powered by the simultaneous movement of another solute, typically an ion like sodium, down its own gradient. This process does not directly consume ATP but relies on the electrochemical gradient established by primary active transporters. Examples include the sodium-glucose symporter, which uses the sodium gradient to import glucose into cells.

175. (A) Both A and R are true and R is the correct explanation of A
Ultrafiltration is an effective technique for separating proteins from smaller contaminants because it uses membranes with specific molecular weight cut-offs. Under applied pressure, water and small molecules like salts pass through the membrane pores, while larger proteins are retained. This process allows for both the purification and concentration of protein samples, making it a valuable tool in biochemical research and industry.

176. (A) I and III
Eukaryotic cells are defined by having eighty S ribosomes in the cytosol and genetic material organized into linear chromosomes within a nucleus. Unlike prokaryotes, they do not have a nucleoid region or a peptidoglycan cell wall. These structural differences reflect the increased complexity and compartmentalization of eukaryotic organisms, which support more specialized and diverse metabolic and genetic regulatory processes within the cell.

177. (A) Histidine side chains are the major contributors to buffering near physiological pH
Proteins are versatile buffers because they contain various amino acid residues with ionizable side groups. Among these, the imidazole group of histidine is particularly important because its pKa is approximately six, which is close to the physiological pH of seven point four. This proximity allows histidine side chains to effectively donate or accept protons, making proteins like hemoglobin excellent buffers in biological systems.

178. (A) II, III, I
During differential centrifugation, cellular components are separated by size and density in a sequential manner. The largest and densest particles, the nuclei, pellet first at the lowest speeds. Mitochondria are smaller and require intermediate speeds to settle. Finally, the smallest components, such as microsomes, require the highest speeds to form a pellet. This hierarchical separation is a fundamental technique in cell biology.

179. (A) Forcing a liquid containing ions through a capillary or porous solid, separating charges
A streaming potential is generated when a liquid containing ions is forced through a narrow capillary or a porous solid under a pressure gradient. As the liquid moves, it carries the mobile ions in the diffuse layer away from the stationary charges at the surface, creating a charge separation and an electrical potential. This biophysical phenomenon is related to other electrokinetic effects like electrophoresis.

180. (C) Cholesterol
The inner mitochondrial membrane is unique among cellular membranes because it is almost entirely devoid of cholesterol. Instead, it is highly enriched with proteins involved in the electron transport chain and a special phospholipid called cardiolipin. This distinctive lipid composition is essential for maintaining the membrane's high impermeability to ions, which is required to sustain the proton gradient for ATP production.

181. (A) P-3, Q-1, R-2, S-4
Indicators are chosen based on the pH range of their color transitions. Phenolphthalein changes from colorless to pink between pH eight point two and ten. Methyl orange transitions around pH three point one to four point four. Bromothymol blue is used for the near-neutral range of six to seven point six. Universal indicators combine several dyes to provide a continuous color change across a very wide pH range.

182. (A) Hypertonic
When a red blood cell is placed in a hypertonic solution, the external solute concentration is higher than that inside the cell. This creates an osmotic gradient that drives water out of the cell across the semipermeable membrane. As the cell loses water, it shrinks and develops a characteristic scalloped or shriveled appearance known as crenation. This physical response demonstrates the cell's reaction to osmotic stress.

183. (C) It synthesizes lipids for the cell
The Golgi apparatus is primarily involved in the modification, sorting, and packaging of proteins, as well as the synthesis of certain carbohydrates. However, it is not the site of lipid synthesis; that function is primarily performed by the smooth endoplasmic reticulum. Misidentifying the Golgi as a lipid factory ignores its actual role as the central sorting hub for the cell's endomembrane system.

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184. (A) I, III and IV
The plasma membrane of a typical animal cell is composed of a complex mixture of phospholipids, cholesterol, and various glycoproteins. Cellulose is a component of plant cell walls, and peptidoglycan is characteristic of bacterial cell walls, neither of which are found in animal membranes. These lipids and proteins work together to create a selective barrier that regulates the entry and exit of substances.

185. (A) Both A and R are true and R is the correct explanation of A
Blood pH is tightly regulated through the coordinated action of chemical buffers and organ systems. Buffers like bicarbonate provide immediate resistance to pH changes, while the lungs can rapidly eliminate volatile carbon dioxide. The kidneys provide a long-term solution by excreting hydrogen ions and regenerating bicarbonate. Together, these mechanisms ensure that metabolic acids do not disrupt the critical physiological environment of the blood.

186. (A) $K_w = [H^+][OH^-]$
The ionic product of water is a fundamental constant defined as the product of the molar concentrations of hydrogen ions and hydroxyl ions in pure water. At twenty-five degrees Celsius, this value is exactly ten to the power of negative fourteen. This constant relationship ensures that if the concentration of one ion increases, the other must decrease proportionally, which is the basis for the pH scale.

187. (A) Concentration gradient
The movement of small solutes across a semipermeable membrane during dialysis is driven by a concentration gradient. Molecules move passively from the area of high concentration inside the dialysis bag to the surrounding area of low concentration until equilibrium is reached. This process allows for the selective removal of small contaminants while retaining larger macromolecules, making it a standard purification technique in biochemistry labs.

188. (A) Sphingolipids and cholesterol
Lipid rafts are specialized microdomains in the plasma membrane that are enriched with sphingolipids and cholesterol. These molecules pack more tightly together than the surrounding phospholipids, creating a more ordered and less fluid environment within the raft. These microdomains are thought to play critical roles in organizing membrane proteins for cell signaling, protein trafficking, and the entry of certain viruses and toxins.

189. (B) Viscosity
Viscosity is a physical property that describes a fluid's internal resistance to flow. Often referred to as internal friction, it reflects the intermolecular forces that impede the movement of fluid layers past one another. High viscosity fluids flow slowly, like honey, while low viscosity fluids flow easily, like water. In biological systems, the viscosity of fluids like blood and mucus significantly impacts their physiological functions.

190. (A) II, I, IV, III
The catalytic cycle of the sodium-potassium ATPase pump begins with the binding of three intracellular sodium ions. ATP is then hydrolyzed, causing the pump to be phosphorylated and change its conformation. This change releases the sodium ions outside the cell and allows two extracellular potassium ions to bind. Finally, the pump is dephosphorylated, returning to its original state and releasing the potassium ions inside.

191. (D) Non-ideal behavior due to ion interactions
In physical chemistry, activity is used instead of molar concentration to account for the non-ideal behavior of species in solution. This non-ideality is primarily caused by electrostatic interactions between dissolved ions, which affect their effective concentration and chemical reactivity. Using activity allows for more accurate predictions of chemical equilibrium, reaction rates, and thermodynamic properties in complex biological and chemical systems where ion concentrations are significant.

192. (A) P-1, Q-2, R-3, S-4
Different biophysical processes are driven by specific gradients. Diffusion is powered by a concentration gradient of the solute. Osmosis is driven by the chemical potential gradient of water. Ultrafiltration requires a hydrostatic pressure gradient to force fluid through a membrane. Electrophoresis depends on an electrical potential gradient to move charged particles. Understanding these driving forces is essential for analyzing how substances move through biological systems.

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193. (D) It is independent of the buffer concentration
Buffer capacity is not independent of the concentration of the buffer components. While the maximum capacity occurs when the pH equals the pKa, the absolute ability of the buffer to resist pH changes increases as the total concentration of the weak acid and its conjugate base increases. A more concentrated buffer can neutralize more added acid or base before the pH changes significantly.

194. (A) Dispersion medium
In a colloidal system, the continuous phase that surrounds the dispersed particles is known as the dispersion medium. It is analogous to the solvent in a true solution. The dispersed phase consists of the particles themselves, which are larger than individual molecules but small enough to remain suspended. Together, these two phases form a colloid, which exhibits unique properties like the Tyndall effect and Brownian motion.

195. (A) I, II and III
The nuclear envelope is a complex double-membrane structure that encloses the nucleus. It is continuous with the rough endoplasmic reticulum and contains nuclear pores that regulate the transport of molecules between the nucleus and the cytosol. Genetic material is stored inside as chromatin. The envelope does not degrade during interphase; instead, it remains intact to protect the DNA until the onset of cell division.

196. (A) Both A and R are true and R is the correct explanation of A
Lyophilic colloids are generally more stable than lyophobic ones because their particles have a strong affinity for the dispersion medium. This results in the formation of a protective hydration shell around each particle, which prevents them from aggregating even if their surface charge is reduced. This high degree of solvation provides a robust stabilization mechanism that lyophobic colloids, which repel the medium, lack.

197. (D) Lysosome
Lysosomes are single-membrane-bound organelles that contain hydrolytic enzymes for intracellular digestion. In contrast, the nucleus, mitochondria, and chloroplasts are all enclosed by double membranes, consisting of two distinct lipid bilayers. The single-membrane structure of the lysosome is sufficient to sequester its digestive enzymes away from the rest of the cytoplasm, protecting the cell's internal components from unwanted degradation.

198. (A) Galactosyltransferase
Galactosyltransferase is an enzyme localized within the cisternae of the Golgi apparatus, where it catalyzes the transfer of galactose to glycoproteins. Because of its specific localization, it is widely used as a marker enzyme to identify the Golgi fraction during subcellular fractionation. Measuring its activity allows researchers to track the distribution and purity of Golgi-derived vesicles throughout the separation and purification process.

199. (B) 1:10
According to the Henderson-Hasselbalch equation, if the pH is one unit below the pKa, the log of the base-to-acid ratio must be negative one. This means the ratio of the conjugate base to the weak acid is one to ten. In this state, the acid is ninety percent protonated and only ten percent dissociated, demonstrating how the pH relative to the pKa dictates the ionization state.

200. (C) Particles move until they reach their buoyant density position
Isopycnic ultracentrifugation is a separation technique where particles are placed in a density gradient and centrifuged for an extended period. During the run, each particle migrates through the medium until it reaches the zone where its own buoyant density is exactly equal to that of the surrounding gradient. At this point, the particle stops moving, allowing for precise separation based exclusively on density.

201. (D) It includes the sodium-calcium exchanger (NCX)
Primary active transport directly utilizes energy from ATP hydrolysis to move solutes against their gradients, as seen in the Na^+/K^+ pump. The sodium-calcium exchanger, however, is an example of secondary active transport. It uses the energy from the sodium gradient, not direct ATP hydrolysis, to move calcium out of the cell. Therefore, including the exchanger in the primary category is scientifically incorrect.

202. (A) P-1, Q-2, R-3, S-4
Thermodynamic parameters describe various aspects of biological systems. Enthalpy represents the total heat content. Entropy is a measure of

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disorder and is the main driver of the hydrophobic effect. Gibbs free energy determines whether a metabolic reaction will occur spontaneously. Osmotic pressure is a colligative property that is essential for the regulation of cell volume and water balance in living organisms.

203. (A) Vesicular transport from the ER to the Golgi
Vesicular transport between organelles like the ER and the Golgi is not a passive process. It relies on the cytoskeleton, which provides tracks for motor proteins to actively move the vesicles. Other processes like gas exchange or water movement through aquaporins are primarily driven by simple diffusion or osmosis, which do not require the structural components or energy-consuming mechanisms of the cytoskeletal transport system.

204. (A) I, II, III
Biological systems maintain different pH levels for specific functions. The gastric environment is highly acidic to facilitate digestion. Intracellular phosphate buffers operate at a near-neutral pH, typically around six point eight to seven point two. Blood plasma is maintained at a slightly alkaline pH of seven point four by the bicarbonate system. Arranging these environments by typical pH results in the order: gastric juice, intracellular fluid, then plasma.

205. (A) The dissociation of electrolytes into multiple particles
The van 't Hoff factor is used in colligative property calculations to account for the number of particles a solute produces in solution. For non-electrolytes, the factor is one, but for electrolytes that dissociate into multiple ions, the factor is greater than one. This adjustment is necessary because osmotic pressure depends on the total number of dissolved particles rather than their chemical identity.

206. (A) I, II and IV
Aquaporins are integral membrane proteins that form specialized channels for the rapid and selective transport of water molecules. They operate passively and do not require ATP hydrolysis. Importantly, they are designed to prevent the passage of protons, which is essential for maintaining the electrochemical gradients across membranes. Stating that they use ATP is incorrect, as their function is based on facilitated diffusion.

207. (A) Both A and R are true and R is the correct explanation of A
In size-exclusion chromatography, larger molecules elute first because they are too big to enter the internal pores of the stationary phase beads. Instead, they are restricted to the void volume between the beads, traveling a shorter and more direct path through the column. Smaller molecules enter the pores and take a much longer, more tortuous path, resulting in their delayed elution.

208. (A) Sialic acid residues on glycoproteins and glycolipids
The extracellular surface of most animal cell membranes carries a net negative charge, primarily due to the presence of sialic acid residues. These acidic sugar molecules are attached to the carbohydrate chains of membrane-bound glycoproteins and glycolipids. This negative charge is important for cell-cell interactions, preventing unwanted aggregation, and influencing the binding of various ligands and signaling molecules to the cell surface.

209. (B) Radius
The diffusion coefficient of a spherical molecule in a liquid is inversely proportional to its radius, as described by the Stokes-Einstein equation. This means that larger molecules experience greater frictional resistance from the solvent, causing them to diffuse more slowly than smaller ones. Other factors like temperature also affect the coefficient, but the relationship with molecular size is a fundamental inverse proportion.

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210. (B) The protein will migrate rapidly toward the anode at its pI during electrophoresis
At its isoelectric point, a protein has a net charge of zero. During electrophoresis, a molecule must have a net charge to move through the electric field. Therefore, at its isoelectric point, the protein will not migrate at all toward either the anode or the cathode. Stating that it will migrate rapidly is incorrect, as this pH represents the point of zero electrophoretic mobility.

211. (B) Lewis theory
The Lewis theory provides a broad definition of acids and bases that focuses on electron pairs. According to this model, an acid is any chemical species that acts as an electron pair acceptor, while a base is an electron pair donor. This theory is more inclusive than the proton-

based definitions, as it applies to many chemical reactions that do not involve hydrogen ions.

212. (A) P-1, Q-2, R-3, S-4
Membrane transport proteins have specialized roles. $GLUT_4$ facilitates insulin-dependent glucose uptake. CFTR functions as a regulated chloride ion channel. $SGLT_1$ is a symporter that uses the sodium gradient to import glucose into intestinal cells. V-type ATPases are proton pumps that maintain the acidic environment of lysosomes. These proteins are essential for nutrient uptake, ion balance, and the proper function of cellular organelles.

213. (A) 0.4 M
To calculate the ionic strength of this mixture, one must consider all contributing ions: sodium, calcium, and chloride. Summing the product of each ion's concentration and the square of its charge gives a total value of zero point eight. Dividing this by two results in an ionic strength of zero point four molar. This parameter is crucial for determining activity coefficients in complex solutions.

214. (A) Steric hindrance and pore size
The movement of large macromolecules across capillary walls is restricted by physical barriers, primarily steric hindrance and the size of the pores in the endothelial layer. These pores act as a filter, allowing small molecules and water to pass easily while retaining larger proteins in the blood. This selective permeability is essential for maintaining the osmotic pressure of the plasma and regulating fluid balance.

215. (A) I and II
Cell lysis can be achieved using various techniques. Detergents work by solubilizing the lipid bilayer, while sonication uses sound waves to shear DNA and disrupt structures, effectively decreasing extract viscosity. Osmotic shock involves using a hypotonic solution, not a hypertonic one, to cause cells to swell and burst. Therefore, the third statement is incorrect as it describes the wrong osmotic conditions for lysis.

216. (A) Both A and R are true and R is the correct explanation of A
Glycolipids are found exclusively on the extracellular leaflet of the plasma membrane. this asymmetry is established during their synthesis because the enzymes that add carbohydrate residues are located inside the lumen of the Golgi apparatus. Once these lipids are transported to the plasma membrane via vesicles, the modified portions end up facing the exterior of the cell, where they participate in cell recognition.

217. (B) Regenerated cellulose
Regenerated cellulose is the standard material used to manufacture semipermeable dialysis tubing for laboratory use. It provides a semi-flexible, porous structure with well-defined molecular weight cut-offs, allowing small solutes to diffuse through while retaining larger macromolecules. This material is chemically resistant and relatively inexpensive, making it ideal for the desalination and purification of protein and nucleic acid samples in biochemical research.

218. (A) Cohesion
Cohesion is the property of water that causes its molecules to be attracted to one another through extensive hydrogen bonding. This internal attraction creates strong forces within the liquid, contributing to its high surface tension and the ability of water to form droplets. It also works in conjunction with adhesion to support the transport of water through narrow vessels in plants and other organisms.

219. (B) Higher solvent density increases the sedimentation rate
In reality, a higher solvent density decreases the sedimentation rate of a particle because it increases the buoyant force opposing the sedimentation. As the density of the medium approaches the density of the particle, the net force acting on the particle decreases, slowing its movement. The other statements regarding mass, shape, and angular velocity correctly describe factors that influence the sedimentation coefficient and velocity.

220. (A) I, II, III, IV
The activation of a G-protein coupled receptor follows a precise sequence. It begins with the binding of a ligand to the receptor, followed by the exchange of GDP for GTP on the G-protein. The alpha subunit then dissociates to activate an effector enzyme, initiating a signal cascade. The process is terminated when the alpha subunit hydrolyzes its bound GTP back into GDP.

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221. (B) Entropy
Entropy is a thermodynamic parameter that quantifies the degree of disorder or randomness within a system. In biological processes, the tendency for entropy to increase drives many phenomena, such as the folding of proteins and the formation of lipid bilayers through the hydrophobic effect. A decrease in local entropy, such as building complex molecules, must be offset by a larger increase in the entropy of the surroundings.

222. (A) P-1, Q-2, R-3, S-4
Lipids form various structures based on their environment. A micelle is a monolayer sphere with a hydrophobic core. A liposome is a spherical vesicle with an aqueous core enclosed by a bilayer. A bilayer itself is a planar two-leaflet sheet. Chylomicrons are specialized lipoprotein particles used for transporting dietary lipids through the circulatory system. These different arrangements are essential for lipid transport and membrane integrity.

223. (A) Sodium ions
The transport of glucose into intestinal epithelial cells is a form of secondary active transport mediated by the $SGLT_1$ symporter. It uses the potential energy from the sodium gradient, which is maintained by the Na^+/K^+ ATPase, to drive glucose into the cell against its concentration gradient. The downhill movement of sodium ions provides the necessary energy to transport glucose simultaneously into the cytoplasm.

224. (A) Decreased pCO_2
A left shift of the oxygen-hemoglobin dissociation curve indicates that hemoglobin has a higher affinity for oxygen, meaning it binds more tightly and releases it less readily. This occurs under conditions such as decreased carbon dioxide levels, increased pH, or lower temperatures. These changes typically happen in the lungs, facilitating the loading of oxygen into the blood for transport to the tissues.

225. (A) I and II
Lysosomes function optimally in acidic conditions and are essential for degrading material taken up by endocytosis and recycling cellular components. They are enclosed by a protective single membrane to sequester their powerful hydrolytic enzymes and are formed through the endomembrane system, not synthesized directly in the cytosol. The third and fourth statements are incorrect regarding their structure and biogenesis.

226. (A) Both A and R are true and R is the correct explanation of A
The dielectric constant of a solvent is a critical factor in determining the strength of electrostatic interactions between dissolved ions. According to Coulomb's law, the force between two charges is inversely proportional to the dielectric constant of the medium. Therefore, a solvent with a high dielectric constant, like water, significantly reduces these attractive or repulsive forces, allowing ionic compounds to dissociate and dissolve easily.

227. (A) Hydrogen ions
The glass electrode used in pH meters operates by measuring the potential difference across a specialized thin glass membrane. This membrane is selectively permeable to hydrogen ions, allowing them to interact with the glass surface and establish a potential that is proportional to the logarithm of the hydrogen ion activity. This electrical signal is then converted into a pH reading for the solution being measured.

228. (A) It accurately models multilayer adsorption
The Langmuir adsorption isotherm is specifically designed to model monolayer adsorption, where only a single layer of molecules binds to the surface. It assumes that all binding sites are equivalent and that there are no interactions between adsorbed molecules. Stating that it accurately models multilayer adsorption is incorrect, as that requires more complex theories like the BET isotherm which account for multiple layers.

229. (A) Increase in solution volume per unit mass of added protein
The partial specific volume of a protein is defined as the increase in the total volume of a solution per unit mass of protein added. It reflects the effective volume occupied by the protein in solution and is an important parameter in biophysical techniques such as analytical ultracentrifugation and density measurements. This value helps determine molecular weight, protein conformation, and interactions in solution.

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230. (A) I, II, III
In a typical animal cell, the dry weight is composed mainly of proteins, which are the most abundant macromolecules. Lipids are the next most significant component, forming the structural basis of all membranes. Carbohydrates are present in smaller amounts, often as part of glycoproteins or stored energy. This results in the increasing sequence of contribution from carbohydrates to lipids, and finally, to proteins.

231. (B) Smooth Endoplasmic Reticulum
The smooth endoplasmic reticulum lacks ribosomes and is primarily involved in lipid and steroid synthesis, as well as detoxification and calcium storage. In contrast, the rough ER, Golgi apparatus, and ribosomes are all directly involved in the synthesis or modification of proteins. Misidentifying the smooth ER as a protein-processing site overlooks its specialized role in non-protein metabolic pathways within the cell.

232. (D) P-2, Q-1, R-2, S-2
Cell types are distinguished by specific structural features. Prokaryotic bacteria lack membrane-bound organelles, possess peptidoglycan cell walls, and are exclusively unicellular. Eukaryotic animal cells contain diversos organelles and have cholesterol in their plasma membranes but lack a cell wall. Understanding these differences is fundamental to biology, as it reflects the major evolutionary divide between these two primary domains of life.

233. (A) Competition for water of hydration between the protein and the salt ions
The "salating out" phenomenon occurs when high concentrations of salts, such as ammonium sulfate, are added to a protein solution. The salt ions have a high affinity for water and compete with the protein for its hydration shell. As the protein loses its surrounding water molecules, its hydrophobic patches become exposed, causing the proteins to aggregate and precipitate out of the solution.

234. (A) The conjugate base
In the context of the Henderson-Hasselbalch equation, the term $[A^-]$ represents the molar concentration of the conjugate base of the weak acid. This species is formed when the weak acid, denoted as $[HA]$, loses a proton. The ratio between these two concentrations, along with the pKa of the acid, determines the final pH and buffering capacity of the solution being analyzed.

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235. (A) I, II and IV
Brownian motion is the random movement of colloidal particles caused by solvent bombardment. It helps prevent settling due to gravity and is more intense for smaller particles or in less viscous fluids. The motion does not cease at twenty-five degrees Celsius; it only stops at absolute zero. Therefore, the third statement is incorrect as thermal energy continues to drive this motion at room temperature.

236. (D) A is false but R is true
The fluid mosaic model describes cell membranes as dynamic and fluid structures, not rigid ones. While it is true that phospholipids and many proteins can undergo rapid lateral diffusion within the membrane, the claim that membranes are rigid two-dimensional structures is false. The fluidity is a central tenet of the model, allowing for membrane flexibility, repair, and essential functional interactions.

237. (A) Availability of ATP in the cytoplasm
Facilitated diffusion is a passive transport process that does not require the expenditure of metabolic energy. Therefore, the availability of ATP in the cytoplasm has no direct influence on its rate. The process is instead governed by the concentration gradient, the number of available carrier proteins, and the affinity of those carriers for the solute, all of which determine the transport kinetics.

238. (B) They permanently neutralize and remove excess acid from the body
Physiological buffers provide a temporary defense by resisting pH changes, but they do not permanently remove acid from the body. That critical role is performed by the lungs through the elimination of carbon dioxide and by the kidneys through the excretion of hydrogen ions. Stating that buffers permanently remove acid is incorrect, as their function is to minimize the immediate impact of acid-base imbalances.

239. (A) Pressure-driven separation of molecules through a semipermeable membrane based on size
Ultrafiltration is a separation process where a hydrostatic pressure gradient forces a liquid through a semipermeable membrane. The

membrane pores are sized to allow water and small solutes to pass while retaining larger macromolecules like proteins. This method is widely used for concentrating and purifying protein samples, as well as in physiological processes like glomerular filtration in the kidneys for urine production.

240. (A) I, III, II, IV
Differential centrifugation separates cellular components in a specific order based on size and density. The first pellet obtained at low speed contains unbroken cells and nuclei. Increasing the speed results in a second pellet containing mitochondria and lysosomes. A third, very high-speed run yields microsomes. The remaining liquid, or supernatant, contains the soluble cytosolic proteins. This sequence is essential for isolating specific organelles.

241. (A) Extensive hydrogen bonding
The high surface tension of water is primarily caused by the extensive hydrogen bonding between its molecules. At the air-water interface, water molecules are pulled inward by their neighbors below, creating a contractive force that minimizes the surface area. This property allows certain insects to walk on water and is essential for the structure and function of various biological systems, including lung mechanics.

242. (B) Respiratory alkalosis
Respiratory alkalosis is characterized by an increase in blood pH above seven point four five, caused by a primary decrease in the partial pressure of carbon dioxide. This condition often results from hyperventilation, where the body eliminates carbon dioxide faster than it is produced. The resulting reduction in carbonic acid leads to a more alkaline blood environment, which can affect nerve and muscle function.

243. (A) Highly positive or highly negative, preventing coagulation
For a colloidal dispersion to remain stable, the zeta potential of the particles should be either highly positive or highly negative, typically outside the range of plus or minus thirty millivolts. These high potentials indicate strong electrostatic repulsion between the particles, which prevents them from colliding and aggregating. A zeta potential near zero often leads to particle coagulation and the collapse of the colloid.

244. (A) Amphoteric
An amphoteric molecule is one that can act as both an acid and a base depending on the environmental conditions. Amino acids are classic examples of amphoteric substances because they contain both an acidic carboxyl group and a basic amino group. This dual nature allows them to react with either acids or bases, providing them with internal buffering capacity and influencing their behavior in biological systems.

245. (A) I, II and III
Biological membranes are complex, asymmetric bilayers that are selectively permeable and can undergo phase transitions. They allow small nonpolar molecules to pass but are not freely permeable to large, water-soluble molecules, which require specific transport proteins. Therefore, the fourth statement is incorrect. The structural and functional characteristics of membranes are vital for maintaining the identity and environment of the cell and its organelles.

246. (A) Both A and R are true and R is the correct explanation of A
Mitochondria are famously called the powerhouses of the cell because they are the primary site for ATP production. Through the process of oxidative phosphorylation, they convert the energy stored in nutrients into a form that the cell can readily use. This activity occurs within the inner membrane and matrix, providing the necessary energy for most cellular work and metabolic processes in eukaryotes.

247. (A) Chemical composition of the centrifuge tube
The rate of sedimentation for a particle depends on its physical properties, the characteristics of the solvent, and the strength of the centrifugal field. While density, viscosity, and particle size are all critical factors, the chemical composition of the centrifuge tube itself does not influence how the particle moves through the liquid. Researchers focus on solvent properties and rotor speed to control the separation.

248. (A) Diffusible cation concentration equals anion concentration on protein side
In a Gibbs-Donnan equilibrium, the presence of non-diffusible charged proteins ensures that the concentrations of diffusible cations and anions on that side are not equal. To maintain overall electrical neutrality, the total positive charge must equal the total negative charge, including

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the protein. Stating that the diffusible cation and anion concentrations are equal on the protein side is therefore a fundamental misunderstanding.

249. (A) It is generally a very slow process
Dialysis is a gentle and effective way to purify macromolecules, but its main disadvantage is that it is a very slow process, often requiring several hours or even days to reach equilibrium. It relies on passive diffusion, which takes time to move solutes across the membrane. While other methods might be faster, they often subject the sample to more mechanical stress or high temperatures.

250. (A) II, I, IV, III
Preparing a density gradient for isopycnic centrifugation follows a specific order. First, a solution with a continuous density gradient is prepared in a centrifuge tube. The biological sample is then carefully layered on top of this gradient. The tube is centrifuged until the particles reach their equilibrium density positions. Finally, the tube is fractionated to collect the separated components for analysis.

251. (A) Catenation
Catenation is the unique ability of carbon atoms to form long, stable chains and complex rings by bonding with one another. This property is the foundation of organic chemistry and biochemistry, as it allows for the incredible structural diversity found in biological macromolecules like proteins, lipids, and nucleic acids. Without catenation, the complex molecular architecture necessary for life processes could not exist.

252. (A) P-1, Q-2, R-3, S-4
Cellular components have distinct chemical compositions. The nucleolus is rich in RNA and proteins for ribosome assembly. The cytosol consists primarily of water, ions, and soluble proteins. The plasma membrane is composed of phospholipids, cholesterol, and integral proteins. Chromatin is the complex of DNA and histones found within the nucleus. These varied compositions reflect the specialized functions each compartment performs within the cell.

253. (A) Specific heat
Specific heat capacity is the biophysical constant that measures how much heat energy is required to raise the temperature of a substance. Substances with high specific heat, like water, resist temperature changes because they can absorb significant energy with only a small increase in thermal motion. This property is essential for maintaining stable body temperatures in living organisms despite fluctuations in the external environment.

254. (A) 5.95
According to the Henderson-Hasselbalch equation, the pH is equal to the pKa plus the log of the base-to-acid ratio. For ninety percent dissociation, the ratio is nine to one. Adding the log of nine, which is approximately zero point nine five, to the pKa of five point zero results in a final pH of five point nine five for the solution.

255. (A) I and II
Light scattering techniques provide valuable information about macromolecules. Static scattering is used to calculate the average molecular weight, while dynamic scattering measures fluctuations to determine the diffusion coefficient and hydrodynamic radius. However, light scattering intensity generally increases with particle size, making the third statement incorrect. These methods are essential for characterizing the physical state and size distribution of biological molecules in solution.

256. (A) Both A and R are true and R is the correct explanation of A
Secondary active transport is fundamentally linked to the activity of primary active transporters. Primary transporters, such as the Na^+/K^+ ATPase, use ATP to establish and maintain strong ion gradients across the cell membrane. These gradients store potential energy, which secondary transporters then harness to move other solutes against their concentration gradients. Without the continuous work of primary transport, secondary transport would cease.

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257. (A) Protonated and deprotonated forms have different absorption spectra
Acid-base indicators are weak acids or bases that change color based on the pH of the solution. This occurs because the protonated and deprotonated forms of the indicator molecule have different electronic structures, which leads to different light absorption spectra. As the pH shifts, the equilibrium between these two forms changes, causing a visible color transition that reflects the hydrogen ion concentration.

258. (B) Osmotic shock utilizes a hypertonic solution to burst cells
Osmotic shock actually involves placing cells in a hypotonic solution, which causes them to take up water rapidly, swell, and eventually burst. Using a hypertonic solution would cause the cells to shrink rather than lyse. The other methods listed, including the use of shearing forces, cavitation, and high pressure, are all valid and common techniques for disrupting cell membranes in the laboratory.

259. (A) Tyndall effect
The Tyndall effect is a physical property of colloidal systems where light is scattered by suspended particles, making the beam visible to the observer. This scattering occurs because the particles are large enough to interact with the wavelength of light. It is a reliable way to distinguish between a true solution, which does not scatter light, and a colloidal dispersion, which does.

260. (A) II, I, III, IV
Biological measurements utilize different units of length. The angstrom is the smallest in this series, followed by the nanometer, which is ten times larger. The micrometer is one thousand times larger than the nanometer and is used for cell dimensions. Finally, the millimeter is the largest unit here. Arranging them from smallest to largest results in the sequence: angstrom, nanometer, micrometer, millimeter.

261. (A) Effective dissipation of excess body heat through sweating or panting
The high latent heat of vaporization of water is physiologically critical for thermoregulation. When animals sweat or pant, the evaporation of water from their surfaces consumes a large amount of heat energy from the body. This efficient cooling mechanism allows organisms to maintain a stable internal temperature even in hot environments or during periods of intense physical activity, preventing potentially dangerous overheating.

262. (A) P-1, Q-2, R-3, S-4
Membrane proteins interact with the lipid bilayer in different ways. Single-pass integral proteins cross once using an alpha-helix, while multi-pass proteins weave through several times. Peripheral proteins associate loosely with the surface through non-covalent bonds. Lipid-anchored proteins are covalently attached to a lipid molecule embedded in the bilayer. These diverse structural arrangements are essential for the wide variety of functions these proteins perform.

263. (A) Hemolysis
Diluting a solution containing red blood cells with pure water creates a highly hypotonic environment. This results in a significant osmotic gradient that drives water into the cells. Because animal cells lack a rigid cell wall, they continue to swell until the plasma membrane can no longer withstand the internal pressure, leading to rupture and the release of hemoglobin, a process known as hemolysis.

264. (A) Bicarbonate buffer
The bicarbonate buffer system is the predominant mechanism for maintaining pH in the extracellular fluids of animals, including the interstitial fluid. It consists of dissolved carbon dioxide and bicarbonate ions in equilibrium. This system is particularly effective because it is open to the environment, allowing the body to rapidly adjust levels through respiration and renal activity, ensuring a stable environment for tissues.

265. (A) I, II and III
The eukaryotic nucleus is a double-membrane-bound organelle that contains the cell's genetic material and a nucleolus for ribosome assembly. However, it does not synthesize ATP directly via glycolysis; that process occurs in the cytosol, and most ATP is produced in the mitochondria. Stating that the nucleus performs glycolysis is incorrect, as it is specialized for genetic storage, transcription, and ribogenic activities.

266. (A) Both A and R are true and R is the correct explanation of A
The Na^+/K^+ ATPase is classified as an electrogenic pump because its activity results in a net transfer of positive charge across the membrane. In each cycle, it moves three sodium ions out for every two potassium ions it brings in, creating a net outward current. This charge separation contributes directly to the electrical potential difference between the inside and outside of the cell.

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267. (A) It has a very low degree of ionization
Pure water is a poor conductor of electricity because it undergoes self-ionization to a very limited extent. Only a tiny fraction of water molecules dissociate into hydrogen and hydroxyl ions. Since electrical conductivity in liquids depends on the presence of mobile ions to carry the current, the low concentration of these ions in pure water results in extremely low electrical conductivity values.

268. (A) It requires specialized transport proteins
Simple diffusion is a passive process where molecules move directly through the phospholipid bilayer without the help of specialized transport proteins. It is driven by the concentration gradient and is most effective for small, nonpolar molecules like oxygen and carbon dioxide. Facilitated diffusion and active transport are the mechanisms that require carrier proteins, distinguishing them from the simpler passive movement described here.

269. (A) Henry's law
Henry's law states that at a constant temperature, the amount of a specific gas that dissolves in a given volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with the liquid. This principle is fundamental for understanding how oxygen and carbon dioxide dissolve in blood and other biological fluids, facilitating gas exchange in the lungs and tissues.

270. (A) I, II, III
Cellular compartments maintain different pH levels for their functions. Lysosomes are the most acidic to activate digestive enzymes. The cytosol is near-neutral, typically around pH seven point two. The mitochondrial matrix is the most alkaline in this series, often reaching pH eight point zero to support the proton gradient for ATP synthesis. Arranging them from most acidic to most alkaline gives the order: lysosome, cytosol, matrix.

271. (A) Capillarity
Capillarity is the physical phenomenon where a liquid spontaneously rises or falls in a narrow tube, such as a capillary. It results from a balance between the cohesive forces within the liquid and the adhesive forces between the liquid and the tube wall. This effect is important in biology for the transport of fluids through small vessels in plants and the circulatory systems.

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272. (A) P-1, Q-2, R-3, S-4
Enzymes are essential markers for identifying cellular organelles. Acid phosphatase is characteristic of lysosomal degradation. Catalase is responsible for peroxisomal detoxification of hydrogen peroxide. Cytochrome c oxidase is a vital part of the mitochondrial electron transport chain. RNA polymerase is the enzyme dedicated to nuclear transcription. These specific locations and functions are fundamental to the organization and metabolic regulation of the eukaryotic cell.

273. (A) Henderson-Hasselbalch equation
The Henderson-Hasselbalch equation is a fundamental mathematical relationship used to calculate the pH of a buffer solution. It relates the pH to the pKa of the weak acid and the logarithm of the ratio between the conjugate base and acid concentrations. This equation is widely used in medicine and biology to understand acid-base physiology and to prepare stable buffers for experiments.

274. (A) It is generally a very slow process
While dialysis is a gentle method for purifying proteins, its main practical disadvantage is the significant amount of time it takes to reach equilibrium. Because it relies on passive diffusion through the membrane, the process can take several hours or even days. This slow speed can be a drawback when researchers need to purify samples quickly to maintain protein stability or activity.

275. (A) I and III
Colloidal particles are small enough to pass through ordinary filter paper but large enough to scatter light, exhibiting the Tyndall effect. They are generally too small to be seen with a standard light microscope and do not settle rapidly under gravity due to Brownian motion. Therefore, the second and fourth statements are incorrect. Colloids occupy an intermediate size range between true solutions and suspensions.

276. (A) Both A and R are true and R is the correct explanation of A
The sedimentation rate of a macromolecule in an ultracentrifuge increases as the rotor speed increases because the centrifugal force is proportional to the square of the angular velocity. Higher speeds apply a much stronger outward force, causing particles to move more rapidly

through the solvent. This relationship is essential for achieving efficient and timely separation of various biological molecules and organelles.

277. (A) Amino acids
Amino acids are classic examples of amphoteric biological molecules because they contain both an acidic carboxyl group and a basic amino group. This structure allows them to react with both acids and bases and to exist as zwitterions at physiological pH. This amphoteric nature is crucial for their function as buffers and dictates their chemical behavior during the formation of proteins and peptides.

278. (A) It is completely independent of the valency of the ions
Ionic strength is fundamentally dependent on the valency of the ions present in the solution. In fact, the charge of each ion is squared in the ionic strength formula, meaning that multivalent ions have a much larger impact than monovalent ones at the same concentration. Stating that it is independent of valency is incorrect, as the electrical charge is a primary factor.

279. (A) Ratio of activity to concentration
The activity coefficient is defined as the ratio of the activity, or effective concentration, of an ion to its actual molar concentration. This coefficient quantifies the degree to which a solution deviates from ideal behavior due to interionic interactions. By multiplying the concentration by this factor, one obtains the activity, which is the value required for accurate thermodynamic and electrochemical calculations.

280. (A) I, II, III, IV
Receptor-mediated endocytosis follows a precise sequence. It begins with the binding of a ligand to its specific receptor, followed by the clustering of these complexes into clathrin-coated pits. The pits then invaginate to form coated vesicles, which eventually lose their clathrin coat. Finally, the uncoated vesicles fuse with endosomes for further processing and sorting of the ligand and receptor components.

281. (A) Dialysis
Dialysis is a passive separation technique that removes small solutes from a solution of macromolecules by allowing them to diffuse through a semipermeable membrane into a large volume of buffer. It relies on the concentration gradient between the two compartments and the pore size of the membrane, which retains large proteins while allowing salts and small molecules to pass until equilibrium is achieved.

282. (A) P-1, Q-2, R-3, S-4
Cell junctions provide specialized structural and functional connections between cells. Tight junctions seal adjacent cells to prevent fluid leakage. Desmosomes mechanically anchor cells together to resist shearing forces. Gap junctions provide cytoplasmic channels for direct intercellular communication. Hemidesmosomes anchor cells to the underlying extracellular matrix or basal lamina. These connections are vital for maintaining the integrity and coordinated function of animal tissues.

283. (A) Respiratory acidosis
Respiratory acidosis occurs when the blood pH drops below the normal range due to an elevation in the partial pressure of carbon dioxide. This condition is usually caused by hypoventilation, which prevents the lungs from eliminating carbon dioxide efficiently. The resulting buildup of dissolved gas leads to an increase in carbonic acid and a subsequent rise in hydrogen ion concentration in the blood.

284. (A) Tonicity
Tonicity is a measure of the effective osmotic pressure gradient across a semipermeable membrane, representing the ability of an extracellular solution to cause a cell to gain or lose water. It depends exclusively on the concentration of solutes that cannot cross the membrane. A solution's tonicity determines whether it is isotonic, hypotonic, or hypertonic, influencing the final volume and shape of cells.

285. (A) I and II
The Svedberg unit is a measure of sedimentation velocity that depends on both the mass and the shape of the particle. Because the coefficient accounts for frictional resistance, which is shape-dependent, it is not strictly additive. Therefore, the combination of two subunits often results in a total coefficient smaller than the sum of the individuals. The third statement is incorrect regarding shape independence.

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286. (A) Both A and R are true and R is the correct explanation of A
The asymmetrical distribution of phosphatidylserine in the plasma membrane is actively maintained by flippases. These enzymes use energy from ATP to selectively transport phosphatidylserine from the outer leaflet to the inner leaflet. This sequestration is crucial because the exposure of phosphatidylserine on the outer surface serves as a signal for programmed cell death, or apoptosis, in many animal cell types.

287. (A) Rayleigh-Tyndall effect
The Rayleigh-Tyndall effect describes the scattering of light by particles in a colloidal dispersion. This phenomenon occurs because the dispersed particles are large enough to deflect the incident light rays in multiple directions. The scattered light makes the path of the beam visible as it passes through the medium, providing a simple way to identify colloids and study their particle properties.

288. (A) It is entirely devoid of structural elements
The cytosol is not a simple, structureless aqueous solution; it contains a complex network of proteins known as the cytoskeleton. This network provides structural support, organizes organelles, and facilitates intracellular transport. Stating that the cytosol is entirely devoid of structural elements is incorrect, as the cytoskeleton is a fundamental component of the eukaryotic cytoplasm, influencing cell shape and movement in living organisms.

289. (A) Exocytosis
Exocytosis is the primary mechanism for the bulk transport of macromolecules out of a eukaryotic cell. During this process, substances destined for secretion are packaged into vesicles that move toward the plasma membrane. Upon fusion of the vesicle with the membrane, the contents are released into the extracellular space. This pathway is essential for secreting hormones, enzymes, and other large biological molecules.

290. (A) I, II, III, IV
An enzyme-catalyzed reaction begins with the substrate binding to the enzyme's active site, forming an enzyme-substrate complex. The reaction then passes through a transition state where chemical changes occur. Once the reaction is complete, the products are formed while still associated with the enzyme. Finally, the products are released from the active site, allowing the enzyme to be reused for subsequent cycles.

291. (A) High heat of vaporization
The efficient cooling effect of sweating is directly caused by the high heat of vaporization of water. As sweat evaporates from the skin, it must absorb a significant amount of heat energy to overcome the hydrogen bonds between water molecules. This energy is taken from the body, leading to a substantial cooling effect with minimal water loss, which is essential for thermoregulation.

292. (A) P-1, Q-2, R-3, S-4
Subcellular fractionation involves several key terms. The homogenate is the un-fractionated mixture of disrupted cells. The supernatant is the liquid portion remaining after centrifugation, while the pellet is the solid residue that collects at the bottom. A gradient is a solution that varies continuously in density throughout the centrifuge tube. These components are essential for isolating and analyzing specific cellular organelles.

293. (A) By actively pumping out ions, primarily via the Na^+/K^+ ATPase
Animal cells counteract the increased internal osmotic pressure caused by the Gibbs-Donnan effect by actively pumping ions out of the cell. The sodium-potassium ATPase pump is the primary mechanism, continuously exporting sodium ions to maintain a lower internal osmolarity. This active transport balance prevents the cell from taking up too much water, which would otherwise lead to swelling and eventual rupture.

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294. (A) Separation based on the molecule's ability to enter the pores of a stationary phase matrix
Gel filtration chromatography separates molecules based on their ability to penetrate the pores of a stationary phase matrix. Larger molecules are excluded from the pores and travel faster through the column, while smaller molecules enter the pores and are delayed. This size-based separation is a gentle and effective way to purify proteins and other macromolecules without relying on their charge or chemical affinity.

295. (A) I and II
Viscosity measures a fluid's resistance to flow and is a critical property of biological fluids. Blood viscosity increases with hematocrit, which

is the percentage of red blood cells. However, the viscosity of most liquids generally decreases with increasing temperature, making the third statement incorrect. Understanding these factors is important for analyzing blood flow dynamics and the work required by the circulatory system.

296. (A) Both A and R are true and R is the correct explanation of A
In biological membranes, the spontaneous flip-flop of lipid molecules from one leaflet to the other is extremely rare. This is because moving a polar head group through the hydrophobic core of the bilayer is energetically very unfavorable. This slow rate of transverse diffusion is essential for maintaining the lipid asymmetry of the membrane, which is vital for various cellular signaling and functional processes.

297. (A) Analytical ultracentrifugation
Analytical ultracentrifugation is a powerful technique that uses a high-speed centrifugal field to monitor the sedimentation of macromolecules in real time. By measuring the rate at which molecules move and reach equilibrium, researchers can determine their mass, shape, and interactions in solution. This method provides detailed information about the physical state of proteins and nucleic acids under physiological conditions without the need for labels.

298. (A) It is a component of the inner mitochondrial membrane
Cholesterol is a key component of the plasma membrane, but it is almost entirely absent from the inner mitochondrial membrane. It serves as a precursor for steroid hormones and bile acids and modulates the fluidity of the plasma membrane. Stating that it is a component of the inner mitochondrial membrane is incorrect, as that membrane has a unique, cholesterol-free lipid composition.

299. (A) The exact pressure required to stop the net flow of solvent across a semipermeable membrane
Osmotic pressure is defined as the external pressure that must be applied to a solution to prevent the net inward flow of pure solvent across a semipermeable membrane. It is a colligative property, meaning it depends on the number of solute particles rather than their chemical identity. This pressure is essential for regulating water balance and maintaining the structure and volume of biological cells.

300. (A) I, II, III, IV
Selecting a biochemical indicator involves a logical sequence. First, the pH at the titration's equivalence point is determined. An indicator with a pKa close to this pH is identified, ensuring its color change interval overlaps with the steep portion of the titration curve. Finally, the chosen indicator is added to the solution before beginning the titration to provide a visible signal.

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CHAPTER 02
Carbohydrates

2018

1. Which of the following defines an aldose in monosaccharide classification?
(A) Polyhydroxy structure with a terminal aldehyde group
(B) Cyclic ring structure with a single double bond and ketone
(C) Ketone functional group located on the second carbon chain
(D) Saccharide chain permanently prevented from forming pyranose

2003

2. Epimers are a specific type of stereoisomer in carbohydrates. Which of the following best describes them?
(A) Isomers that vary in configuration at the anomeric carbon exclusively
(B) Pair of molecules that are non-superimposable mirror images
(C) Diastereomers differing at exactly one specific chiral center
(D) Stereoisomers that demonstrate a complete lack of optical rotation

2025

3. Which of the following disaccharides is classified as non-reducing due to the involvement of both anomeric carbons in its glycosidic bond?
(A) Trehalose
(B) Maltose
(C) Lactose
(D) Cellobiose

2023

4. What is the primary structural difference between amylose and amylopectin in starch?
(A) Amylose contains alpha-1,6 linkages, while amylopectin utilizes alpha-1,4 bonds
(B) Amylose is a highly branched unit, while amylopectin remains a linear chain
(C) Amylose is composed of galactose, whereas amylopectin consists of glucose
(D) Amylose is linear alpha-1,4; amylopectin is branched via alpha-1,6

2007

5. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Cellulose possesses high tensile strength and resistance to enzymatic degradation.
Reason (R): Cellulose chains are unbranched polymers of beta-1,4-linked glucose units that form extensive intermolecular hydrogen bonds.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

6. Which repeating disaccharide unit is characteristic of hyaluronic acid?
(A) N-acetylglucosamine and galactose
(B) N-acetylgalactosamine and iduronic acid
(C) N-acetylglucosamine and glucuronic acid
(D) Galactosamine and glucuronic acid

2003

7. The antigenic determinant for the A blood group substance essentially requires the terminal addition of which specific sugar residue?
(A) Terminal D-galactose residue
(B) N-acetylglucosamine molecule
(C) L-fucose monosaccharide
(D) N-acetylgalactosamine

2022

8. In bacterial peptidoglycans, the polysaccharide backbone consists of alternating units of:
(A) N-acetylglucosamine and N-acetylmuramic acid
(B) N-acetylgalactosamine and N-acetylneuraminic acid
(C) Glucosamine and muramic acid without acetylation
(D) Glucuronic acid and N-acetylglucosamine

2003

9. In the omega nomenclature system for fatty acids, how is the position of the first double bond determined?

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(A) By counting from the carboxyl carbon as carbon 1
(B) By counting from the terminal methyl carbon as carbon 1
(C) By locating the double bond closest to the mid-chain
(D) By its geometric cis or trans orientation

2005

10. Identify the correct combination of statements regarding fatty acid properties.
I. Trans double bonds increase the melting point compared to cis isomers.
II. Short-chain fatty acids have lower melting points than long-chain ones.
III. Hydrogenation decreases the susceptibility of fats to oxidative rancidity.
IV. Essential fatty acids can be synthesized de novo by mammals.
V. Solubility of fatty acids in water increases with chain length.
Which of the above statements are correct?
(A) I, II and III
(B) I and II
(C) III, IV and V
(D) II, IV and V

2012

11. Which primary function do triacylglycerols serve in mammalian biological systems?
(A) Functioning as the main form of concentrated energy storage
(B) Formation of structural lipid bilayers in membranes
(C) Serving as precursors for eicosanoid synthesis
(D) Acting as emulsifying agents in the small intestine

2025

12. Phosphatidylserine is typically found in biological membranes. What characterizes its distribution in a healthy, resting cell?
(A) Equally distributed between both membrane leaflets
(B) Exclusively located in the outer leaflet environment
(C) Restricted to the inner cytosolic leaflet of the membrane
(D) Spontaneously flips between leaflets without enzymes

2016

13. Which structural component serves as the backbone for sphingomyelin?
(A) Glycerol-3-phosphate
(B) Diacylglycerol
(C) Cholesterol
(D) Sphingosine

2014

14. What distinguishes gangliosides from cerebrosides?
(A) Cerebrosides contain phosphorus, whereas gangliosides do not
(B) Cerebrosides are defined by a complex oligosaccharide moiety
(C) Gangliosides contain one or more sialic acid residues
(D) Gangliosides utilize a glycerol base instead of sphingosine

2011

15. Match the isolation or extraction method with its primary target substance.
List I: (Method)
P. Soxhlet extraction
Q. Bligh-Dyer method
R. Hot aqueous ethanol extraction
S. Dilute acid extraction
List II: (Target)
1. Rapid extraction of total lipids from high-moisture tissues
2. Soluble low-molecular-weight sugars
3. Continuous extraction of neutral lipids from dry samples
4. Pectin from plant cell walls
(A) P-1, Q-3, R-4, S-2
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

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2023

16. What is the fundamental building block of sterols according to the isoprene rule?
(A) Two-carbon acetyl units
(B) Three-carbon malonyl units
(C) Four-carbon butyryl units
(D) Five-carbon isoprene units

2006

17. Which of the following best explains why secondary bile acids are formed?
(A) Intestinal bacteria dehydroxylate primary bile acids
(B) The liver oxidizes cholesterol a second time
(C) Primary bile acids spontaneously degrade in the gallbladder
(D) Pancreatic enzymes cleave taurine conjugates

2019

18. Arachidonic acid serves as the direct precursor for which group of compounds?
(A) Sphingolipids
(B) Bile acids
(C) Eicosanoids
(D) Steroid hormones

2021

19. What is a key limitation when extracting cell wall polysaccharides with hot water alone?
(A) Hemicelluloses and tightly bound pectins remain insoluble
(B) Hot water treatment destroys glycosidic bonds across the chain
(C) Simple soluble sugars undergo rapid polymerization processes
(D) It causes an immediate and irreversible oxidation of structural lipids

2002

20. Identify the incorrect combination of statements regarding carbohydrate chemical tests.
I. Molisch test is specific only for ketoses.
II. Benedict's test detects reducing sugars based on copper reduction.
III. Seliwanoff's test distinguishes ketoses from aldoses.
IV. Barfoed's test distinguishes monosaccharides from disaccharides.
Which of the above statements are incorrect?
(A) I and II
(B) I only
(C) II, III and IV
(D) I and IV

2025

21. Which reagent is utilized in the phenol-sulfuric acid method for total carbohydrate estimation?
(A) Alkaline copper sulfate
(B) Concentrated sulfuric acid and phenol
(C) Phosphomolybdic acid
(D) Anthrone in ethyl acetate

2025

22. In the Folch method for lipid extraction, which solvent mixture is traditionally used?
(A) Hexane and isopropanol (3:2, v/v)
(B) Diethyl ether and ethanol (1:1, v/v)
(C) Chloroform and methanol (2:1, v/v)
(D) Petroleum ether and water (4:1, v/v)

2023

23. What does the saponification number of a fat indicate?
(A) The degree of unsaturation in the fatty acids
(B) The amount of free fatty acids present due to hydrolysis
(C) The susceptibility of the fat to oxidative rancidity
(D) The average molecular weight or chain length of the fatty acids

2012

24. Gas Chromatography (GC) of lipids typically requires which pre-treatment for fatty acid analysis?
(A) Derivatization into fatty acid methyl esters (FAME)
(B) Hydrolysis of complex lipids to free fatty acids via acid
(C) Dissolution in heavy aqueous buffers to stabilize double bonds
(D) Complete hydrogenation of all unsaturated bonds in the sample

2023

25. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Furanose rings are less thermodynamically stable than pyranose rings for aldohexoses.
Reason (R): Furanose rings possess greater angle strain and steric hindrance compared to the six-membered pyranose chair conformation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

26. The phenomenon of mutarotation in aqueous solutions of D-glucose is caused by:
(A) Physical interconversion between D and L enantiomers
(B) Interconversion between anomers via open-chain forms
(C) Shifting of a double bond between first and second carbons
(D) Epimerization of the glucose molecule into a mannose structure

2024

27. Sucrose cannot undergo mutarotation because:
(A) Both anomeric carbons are locked in the glycosidic bond
(B) It lacks an anomeric carbon entirely
(C) It is composed of two identical glucose

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molecules
(D) Its fructose component cannot open into a linear form

2023

28. Which characteristic differentiates glycogen from amylopectin?
(A) Glycogen is an unbranched polymer, while amylopectin is branched
(B) Glycogen utilizes beta-1,4 linkages, whereas amylopectin uses alpha
(C) Glycogen is branched every 8-12 residues, making it highly branched
(D) Glycogen is synthesized in plants, while amylopectin is in animals

2024

29. Chitin is a major structural component of arthropod exoskeletons. What is its monomeric unit?
(A) D-glucosamine
(B) D-galactosamine
(C) N-acetyl-D-muramic acid
(D) N-acetyl-D-glucosamine

2007

30. Identify the correct combination of statements concerning mucopolysaccharides.
I. They are long, unbranched polysaccharides containing repeating disaccharide units.
II. Heparin acts as a powerful intracellular coagulant.
III. Chondroitin sulfate is a major component of cartilage.
IV. Hyaluronic acid is the only sulfated glycosaminoglycan.
V. They generally possess a high negative charge density.
Which of the above statements are correct?
(A) I, II and IV
(B) I, III and V
(C) II, III, IV and V
(D) III and V

2001

31. The O antigen in the ABO blood group system serves as a precursor. What terminal sugar does it possess before further glycosyltransferase action?
(A) N-acetylglucosamine
(B) L-fucose
(C) D-galactose
(D) Sialic acid

2008

32. In the structure of Gram-positive bacterial cell walls, teichoic acids are polymers primarily composed of:
(A) Branched chains consisting of N-acetylglucosamine residues
(B) Long-chain fatty acids esterified directly to mycolic acid
(C) Repeating units of lipopolysaccharides found in the wall
(D) Glycerol or ribitol phosphate cross-linked to peptidoglycan

2022

33. According to the delta nomenclature, a fatty acid denoted as 18:2(delta 9,12) indicates:
(A) An 18-carbon chain with double bonds at the 9th and 12th carbons from the carboxyl end
(B) An 18-carbon chain with double bonds at the 9th and 12th carbons from the methyl end
(C) A 20-carbon chain with two acetyl groups
(D) An 18-carbon chain containing an omega-3 double bond

2018

34. Which of the following is considered an essential fatty acid for humans?
(A) Palmitic acid
(B) Stearic acid
(C) Linoleic acid
(D) Oleic acid

2013

35. Match the physical property or test with its corresponding definition for lipids.
List I: (Property)
P. Iodine value
Q. Acid value
R. Peroxide value
S. Saponification number
List II: (Definition)
1. Milligrams of KOH required to neutralize free fatty acids in 1g of fat
2. Grams of iodine absorbed by 100g of fat, measuring unsaturation
3. Milligrams of KOH required to saponify 1g of fat, reflecting chain length
4. Milliequivalents of active oxygen per kg of fat, measuring primary oxidation
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-2, Q-3, R-1, S-4

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2019

36. High levels of free fatty acids in a lipid sample are a direct indicator of:
(A) High oxidative rancidity
(B) High saturation levels
(C) Elevated saponification numbers
(D) Hydrolytic rancidity

2005

37. Which position on the glycerol backbone of a triacylglycerol in mammals is predominantly esterified with an unsaturated fatty acid?
(A) sn-1
(B) sn-2
(C) sn-3
(D) Both sn-1 and sn-3

2004

38. Phosphatidylinositol plays a crucial role in cellular signaling primarily through:
(A) Serving as a structural anchor for large integral protein complexes
(B) Regulating membrane fluidity through the action of saturated chains
(C) Generating second messengers like IP3 and DAG upon cleavage
(D) Providing a specific recognition site for ribosomal attachment

2021

39. Which genetic disorder is caused by a deficiency in the enzyme ceramidase, leading to the accumulation of ceramide?
(A) Tay-Sachs disease
(B) Niemann-Pick disease
(C) Gaucher disease
(D) Farber disease

2007

40. Select the correct sequential order of steps in the Nelson-Somogyi method for reducing sugar estimation.
(A) Reduction of cupric to cuprous ions → Reaction with arsenomolybdate → Color development → Spectrophotometric reading
(B) Reaction with arsenomolybdate → Reduction of cupric to cuprous ions → Color development → Spectrophotometric reading
(C) Spectrophotometric reading → Reaction with arsenomolybdate → Reduction of cupric to cuprous ions → Color development
(D) Color development → Reduction of cupric to cuprous ions → Spectrophotometric reading → Reaction with arsenomolybdate

2025

41. Sulfolipids, specifically sulfoquinovosyldiacylglycerols (SQDG), are localized primarily in which organelle?
(A) Mitochondria
(B) Chloroplasts
(C) Lysosomes
(D) Endoplasmic reticulum

2001

42. Aminolipids are functionally important because they:
(A) Exclusively form the core of lipid droplets
(B) Can act as zwitterionic surfactants in biological interfaces
(C) Are the main storage form of nitrogen in plant seeds
(D) Lack hydrophobic tails entirely

2012

43. The cyclopentanoperhydrophenanthrene nucleus found in sterols contains how many rings?
(A) Three cyclohexane rings and one cyclopentane ring
(B) Three cyclohexane rings fused in a specific arrangement
(C) Four cyclohexane rings connected through shared bonds
(D) Two cyclohexane rings and two cyclopentane rings fused

2007

44. What defines an amphipathic molecule like a conjugated bile acid?
(A) Existing as a stable zwitterion at a specific physiological pH
(B) Acting as both a Bronsted acid and base in metabolism
(C) Possessing both hydrophilic and hydrophobic regions
(D) Absorbing radiation in both ultraviolet and visible spectra

2007

45. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Thromboxane A_2 induces platelet aggregation and vasoconstriction.
Reason (R): It is synthesized from arachidonic acid via the cyclooxygenase pathway in platelets.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

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(D) A is false but R is true.

2023

46. During the extraction of starch from plant tissues, a weak alkaline solution is sometimes used to:
(A) Hydrolyze the starch into glucose monomers
(B) Promote the crystallization of amylose
(C) Dissolve tightly bound structural proteins
(D) Neutralize the organic acids present in the vacuole

2016

47. The principle of the Anthrone method for carbohydrate estimation involves the reaction of anthrone reagent with:
(A) Free aldehyde groups of aldoses exclusively
(B) Furfural or hydroxymethylfurfural derivatives
(C) Cuprous oxide precipitates
(D) Molybdenum blue complexes

2005

48. Fehling's test is less sensitive than Benedict's test because:
(A) Fehling's solution utilizes a significantly weaker alkali content
(B) Fehling's solution contains Rochelle salt which hinders reaction
(C) Fehling's test is incapable of detecting any monosaccharides
(D) Fehling's reagents are unstable and must be mixed before use

2017

49. In thin-layer chromatography (TLC) of lipid classes, which characteristic predominantly determines the migration rate (Rf value) of neutral lipids when using a non-polar solvent system?
(A) Relative hydrophobicity and lack of polar functional groups
(B) The specific degree of unsaturation present in the acid chains
(C) The precise sequence of acyl groups along the glycerol base
(D) Their specific chemical interaction with the indicator dye

2004

50. Identify the incorrect combination regarding cyclic ring structures of sugars.
I. Pyranose forms are six-membered rings containing oxygen.
II. Furanose forms are five-membered rings.
III. Fructose cannot form a pyranose ring under any conditions.
Which of the above statements are incorrect?
(A) I and II
(B) III only
(C) I and III
(D) II only

2023

51. Which best describes an enantiomer?
(A) Non-superimposable mirror images
(B) Stereoisomers that differ strictly at the anomeric position
(C) Stereoisomers that are perfectly superimposable on each other
(D) Structural isomers possessing different chemical functional groups

2005

52. Trehalose acts as an important protectant in many organisms under stress conditions. Its structure is:
(A) beta-D-galactopyranosyl-(1 → 4) -D-glucopyranose
(B) alpha-D-glucopyranosyl-(1 → 2)-beta-D-fructofuranoside
(C) beta-D-glucopyranosyl-(1 → 4) -D-glucopyranose
(D) alpha-D-glucopyranosyl-(1 → 1)-alpha-D-glucopyranoside

2024

53. Pectin's gelling property is primarily dependent on the degree of esterification of which of its monomeric units?
(A) D-galactose
(B) D-galacturonic acid
(C) L-arabinose
(D) L-rhamnose

2025

54. Which structural feature allows cellulose to form strong microfibrils?
(A) Extensive branching patterns formed via alpha-1,6 linkages
(B) Alternating sequences of beta-1,3 and beta-1,4 connections
(C) Hydrogen bonding between parallel linear beta-1,4 linked chains
(D) Covalent cross-linking occurring between adjacent glucose units

2003

55. Match the storage/structural carbohydrate with its corresponding organismal domain/tissue.
List I: (Carbohydrate)
P. Glycogen

NODIA

Q. Inulin
R. Peptidoglycan
S. Chitin

List II: (Domain/Tissue)

1. Fungal cell walls and arthropods
2. Bacterial cell walls
3. Plant storage roots and tubers
4. Mammalian liver and muscle

(A) P-4, Q-3, R-2, S-1
(B) P-4, Q-2, R-3, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-2, R-4, S-3

2007

56. What repeating disaccharide unit forms chondroitin sulfate?
(A) Glucuronic acid and N-acetylgalactosamine-sulfate
(B) Glucuronic acid and N-acetylglucosamine
(C) Iduronic acid and glucosamine
(D) Galactose and N-acetylglucosamine

2011

57. The B blood group antigen differs from the A antigen by the presence of a terminal:
(A) N-acetylgalactosamine
(B) D-galactose
(C) L-fucose
(D) D-mannose

2018

58. Lipopolysaccharides (LPS) of Gram-negative bacteria contain Lipid A, which acts primarily as a:
(A) Peptidoglycan cross-linker
(B) Endotoxin
(C) Nutrient transporter
(D) Flagellar anchor

2010

59. Which physical factor primarily determines whether a fatty acid is solid or liquid at room temperature?
(A) The presence and number of cis double bonds
(B) The position of the carboxyl group
(C) The synthesis pathway in the cell
(D) The ratio of carbon to oxygen atoms

2010

60. Identify the correct combination of statements concerning acylglycerols.
I. Monoacylglycerols possess potent emulsifying properties.
II. Triacylglycerols form the structural basis of lipid bilayers.
III. Esterification of fatty acids to glycerol is a dehydration synthesis reaction.
IV. Diacylglycerol acts as a crucial secondary messenger in cellular signaling.

Which of the above statements are correct?
(A) I, II and IV
(B) I, III and IV
(C) II and III
(D) I and II

2015

61. Phosphatidylethanolamine is functionally significant in membranes because its conical shape promotes:
(A) Extreme membrane rigidity
(B) Complete impermeability to water
(C) Resistance to phospholipase degradation
(D) Membrane curvature and fusion events

2003

62. Which base forms the core structure of all sphingolipids?
(A) Glycerol, a 3-carbon polyol
(B) Ceramide, a simple fatty acid ester
(C) Sphingosine, an 18-carbon amino alcohol
(D) Inositol, a cyclic sugar alcohol

2001

63. Cerebrosides belong to the class of neutral glycolipids. What type of linkage connects the sugar to the ceramide in a cerebroside?
(A) Phosphodiester bond
(B) beta-glycosidic bond
(C) Ester bond
(D) Amide bond

2019

64. Sitosterol and stigmasterol are phytosterols. How do they differ structurally from animal cholesterol?
(A) They lack the hydroxyl group at the C-3 position
(B) They do not contain the four-ring steroid nucleus
(C) They possess an aromatic A-ring within the system
(D) Possess an extra alkyl group on the side chain at C-24

2008

65. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Ergosterol is medically significant as a target for many antifungal drugs.
Reason (R): Ergosterol is the principal sterol in

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fungal cell membranes, differing from mammalian cholesterol.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

66. The synthesis of secondary bile acids, such as deoxycholic acid, occurs:
(A) Liver via action of cytochrome P450 enzymatic systems
(B) Gallbladder during storage phase of concentrated bile
(C) Intestinal lumen via bacterial flora action
(D) Stomach via simple acid-catalyzed hydrolysis of lipids

2022

67. Leukotrienes, derived from arachidonic acid, are primary mediators of:
(A) Allergic and inflammatory responses like bronchoconstriction
(B) Regulation of gastric acid secretion within the tract
(C) Biosynthesis of cholesterol molecules in hepatic tissues
(D) Disaggregation of platelets during the blood clotting process

2025

68. The extraction of starch using dimethyl sulfoxide (DMSO) is favored in some analytical procedures because:
(A) It completely hydrolyzes starch into glucose
(B) It dissolves starch without causing significant degradation
(C) It specifically extracts amylopectin while precipitating amylose
(D) It inhibits the retrogradation of starch chains

2004

69. Barfoed's test is utilized specifically to differentiate:
(A) Aldoses from ketoses
(B) Monosaccharides from disaccharides
(C) Reducing from non-reducing sugars
(D) Pentoses from hexoses

2024

70. Identify the correct combination regarding quantitative carbohydrate estimation.
I. The phenol-sulfuric acid method detects both reducing and non-reducing sugars.
II. Nelson-Somogyi specifically quantifies reducing sugars.
III. Anthrone method colorimetry is read around 620 nm.
IV. Sulfuric acid in these tests functions merely as a solvent, not a reactant.
V. Non-reducing sugars do not react in the Nelson-Somogyi assay.
Which of the above statements are correct?
(A) I, II, III and V
(B) I, III, IV and V
(C) II, III and IV
(D) I, II and IV

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2004

71. The Soxhlet extraction method is least suitable for extracting which class of lipids?
(A) Naturally occurring free fatty acid chains
(B) Simple neutral triglyceride molecules
(C) High-molecular-weight plant waxes
(D) Highly unsaturated, heat-labile lipids

2016

72. Which measurement indicates the presence of primary oxidation products (hydroperoxides) in fats?
(A) Peroxide value
(B) Saponification number
(C) Acid value
(D) Iodine value

2011

73. In gas chromatography (GC) of fatty acid methyl esters, what is the standard carrier gas used?
(A) Oxygen
(B) Helium or Nitrogen
(C) Carbon dioxide
(D) Methane

2023

74. Which sugar pair correctly identifies two epimers?
(A) D-glucose and D-fructose
(B) D-glucose and D-mannose
(C) D-galactose and D-ribose
(D) D-mannose and D-fructose

2012

75. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Lactose is a reducing sugar.
Reason (R): The glycosidic linkage in lactose involves the anomeric carbon of galactose and the C-4 of glucose, leaving the anomeric carbon of glucose free.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

76. What is the fundamental stereochemical distinction between anomers?
(A) They differ strictly at the penultimate carbon atom
(B) They represent enantiomeric forms of each other
(C) Configuration difference at the new chiral center upon cyclization
(D) They differ in total number of carbon atoms in the ring

2024

77. Glycogen phosphorylase cleaves which specific bonds in glycogen?
(A) beta-1,4 glycosidic bonds
(B) alpha-1,6 glycosidic bonds
(C) beta-1,6 glycosidic bonds
(D) alpha-1,4 glycosidic bonds

2012

78. Which statement about chitin is true?
(A) It is a highly branched polymer easily soluble in water
(B) It acts as the primary energy reserve in insect species
(C) Unbranched chains of beta-1,4 linked N-acetylglucosamine
(D) Structural polymer composed entirely of D-glucuronic acid

2002

79. Heparin is unique among glycosaminoglycans because:
(A) It is unique because it contains no sulfate groups
(B) High density of negative charges acting as an anticoagulant
(C) Functions primarily as a structural element in the matrix
(D) Only glycosaminoglycan possessing a branched structure

2018

80. Select the correct sequence of steps for identifying lipid spots on a TLC plate.
(A) Solvent development → Spotting the sample → Drying → Visualization with iodine vapor
(B) Spotting the sample → Solvent development → Drying → Visualization with iodine vapor
(C) Visualization with iodine vapor → Spotting the sample → Solvent development → Drying
(D) Drying → Solvent development → Spotting the sample → Visualization with iodine vapor

2003

81. Teichoic acids in Gram-positive bacteria are anchored directly to:
(A) The peptidoglycan layer or membrane lipids
(B) The outer lipid bilayer found in Gram-negative cells
(C) The bacterial chromosome within the nucleoid region
(D) The periplasmic space binding protein complexes

2022

82. Which of the following is a naturally occurring trans fatty acid found in small amounts in ruminant fat?
(A) Linolenic acid
(B) Elaidic acid
(C) Vaccenic acid
(D) Arachidonic acid

2008

83. The melting point of a fatty acid decreases with:
(A) An increase in the degree of unsaturation
(B) An increase in chain length
(C) A decrease in the number of double bonds
(D) Complete hydrogenation

2001

84. Identify the correct statement(s) comparing mono- and diacylglycerols to triacylglycerols.
I. Triacylglycerols possess greater emulsifying capabilities.
II. Only triacylglycerols can cross the intestinal lining without hydrolysis.
III. Diacylglycerols cannot act as signaling molecules.
IV. Mono- and diacylglycerols are more polar than triacylglycerols.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) IV only
(D) I, III and IV

2005

85. Match the test to its analytical chemical principle.
List I: (Test)

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P. Molisch test
Q. Benedict's test
R. Seliwanoff's test
S. Bial's test

List II: (Principle)

1. Resorcinol reacts with hydroxymethylfurfural to form a cherry-red color
2. Dehydration to furfural derivatives which react with alpha-naphthol
3. Orcinol reacts with furfural to form a green complex, specific for pentoses
4. Reduction of Cu^{2+} to Cu^{+} forming a brick-red precipitate

(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-1, Q-3, R-2, S-4
(D) P-2, Q-1, R-4, S-3

2004

86. Sphingomyelin is distinguished from other sphingolipids by possessing:
(A) A single D-galactose residue as the polar head group
(B) A complex branched oligosaccharide polar head group
(C) A phosphocholine or phosphoethanolamine head group
(D) A simple hydroxyl head group without modifications

2013

87. Cerebrosides accumulate pathologically in which of the following lysosomal storage diseases?
(A) Tay-Sachs disease
(B) Krabbe disease
(C) Niemann-Pick disease
(D) Gaucher disease

2001

88. What is the defining feature of chloroplast sulfolipids (SQDG)?
(A) Sulfonic acid derivative of a hexose linked to diacylglycerol
(B) Sulfate ester attached directly to the glycerol backbone
(C) Structural lipid with no role in the process of photosynthesis
(D) Lipid that possesses a sphingosine backbone instead of glycerol

2008

89. Aminolipids such as ornithine lipids are frequently found in:
(A) Central nervous system of complex mammalian organisms
(B) Bacteria cultivated under phosphate-limiting conditions
(C) Various types of plant seed oils used in production
(D) Structural cell walls of pathogenic fungal species

2007

90. Identify the correct combination regarding sterols.
I. Cholesterol regulates membrane fluidity in animal cells.
II. Phytosterols can compete with cholesterol for intestinal absorption.
III. Ergosterol is structurally identical to cholesterol except for a ketone group.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2019

91. The conjugation of primary bile acids with glycine or taurine primarily serves to:
(A) Lower pKa to ensure ionization and effectiveness in the intestine
(B) Decreasing their overall solubility within the bile secretions
(C) Facilitating their immediate and complete excretion via urine
(D) Allowing them to be rapidly reabsorbed across the stomach lining

2022

92. Which enzyme acts on arachidonic acid to initiate the synthesis of prostaglandins?
(A) Lipoxygenase
(B) Phospholipase A_2
(C) Cyclooxygenase (COX)
(D) Thromboxane synthase

2009

93. What is the major advantage of using the Bligh-Dyer lipid extraction method over the Folch method?
(A) It is designed to extract exclusively neutral lipid classes
(B) It requires use of completely dehydrated tissue samples
(C) It avoids use of methanol solvent throughout the process
(D) Single-phase system partitioning into two phases upon water addition

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2023

94. Iodine value fundamentally measures:
(A) Mass of iodine liberated from KI by hydroperoxides
(B) Total free fatty acid content present in a specific oil
(C) Halogen absorption by carbon-carbon double bonds in a lipid
(D) Average molecular weight calculated for triacylglycerols

2025

95. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): D-glucose exhibits optical activity in aqueous solution.
Reason (R): It contains four asymmetric carbon atoms in its open-chain form.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

96. During TLC of a biological lipid extract using a hexane:diethyl ether:acetic acid solvent system, which lipid class migrates closest to the solvent front?
(A) Phospholipids
(B) Triacylglycerols
(C) Free fatty acids
(D) Cholesteryl esters

2010

97. Which analytical technique is best suited for determining the exact structural linkages (e.g., $1 \rightarrow 4$ vs $1 \rightarrow 6$) in a complex polysaccharide?
(A) Methylation analysis followed by GC-MS
(B) Benedict's test followed by quantitative spectrophotometry
(C) TLC performed on intact polymer chains
(D) Continuous extraction utilizing Soxhlet apparatus

2021

98. Ketoses can be distinguished from aldoses using Seliwanoff's test because:
(A) Ketoses are incapable of undergoing process of mutarotation
(B) Aldoses form deep blue color instantly when using resorcinol
(C) Ketoses dehydrate more rapidly to form furfurals in acid
(D) Aldoses completely lack a carbonyl group in their molecular chain

2009

99. The pyranose ring of D-glucose adopts which conformation as its most stable state in aqueous solution?
(A) Chair conformation
(B) Boat conformation
(C) Twist-boat conformation
(D) Envelope conformation

2009

100. Identify the incorrect combination regarding disaccharides.
I. Maltose consists of two glucose units linked alpha-1,4.
II. Sucrose consists of glucose and fructose linked alpha-1,beta-2.
III. Cellobiose is an alpha-1,4 linked glucose dimer.
IV. Lactose contains a beta-1,4 linkage.
Which of the above statements is incorrect?
(A) III only
(B) I and III
(C) II and IV
(D) IV only

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2016

101. Which structural characteristic makes amylopectin form a stable suspension in water, unlike amylose?
(A) Its completely linear nature which allows for easy hydration
(B) Presence of sulfate groups on various glucose residues
(C) Its significantly smaller molecular weight compared to amylose
(D) Alpha-1,6 branch points preventing tight crystalline packing

2016

102. What bonding stabilizes the parallel chains of cellulose into tough microfibrils?
(A) Interchain ester bonds between the glucose monomers in the chain
(B) Intramolecular and intermolecular hydrogen bonds
(C) Disulfide bridges formed between the various glucose units
(D) Covalent glycosidic cross-links between the polymer chains

2010

103. Which of the following is a non-sulfated glycosaminoglycan?

(A) Keratan sulfate
(B) Dermatan sulfate
(C) Heparan sulfate
(D) Hyaluronic acid

2002

104. The ABO blood group substances belong primarily to which class of biological molecules?
(A) Simple unbranched homopolysaccharides
(B) Mucopolysaccharides
(C) Lipoproteins
(D) Glycolipids and Glycoproteins

2014

105. Match the specific fatty acid to its common structural designation.
List I: (Fatty Acid)
P. Palmitic acid
Q. Oleic acid
R. Linoleic acid
S. Arachidonic acid
List II: (Designation)
1. 18:1(delta 9)
2. 20:4(delta 5,8,11,14)
3. 16:0
4. 18:2(delta 9,12)
(A) P-3, Q-1, R-4, S-2
(B) P-3, Q-4, R-1, S-2
(C) P-1, Q-3, R-2, S-4
(D) P-2, Q-1, R-4, S-3

2010

106. In bacterial peptidoglycan, the peptide cross-links typically attach to which sugar?
(A) N-acetylglucosamine
(B) N-acetylneuraminic acid
(C) Glucuronic acid
(D) N-acetylmuramic acid

2021

107. What physiological role does the omega-3 fatty acid alpha-linolenic acid play in mammals?
(A) It acts primarily as an energy storage molecule in bone marrow
(B) It forms the rigid outer layer of the stratum corneum
(C) It is an obligate intermediate in cholesterol synthesis
(D) It serves as a precursor for anti-inflammatory eicosanoids

2010

108. Why do unsaturated fatty acids have lower melting points than their saturated counterparts of the same chain length?
(A) Cis double bonds introduce kinks, disrupting chain packing
(B) Unsaturated fatty acids are more hydrophilic and water-soluble
(C) Unsaturated fatty acids have a lower weight by losing oxygen atoms
(D) Trans double bonds allow for a perfectly linear molecular alignment

2019

109. During the hydrogenation of vegetable oils to produce solid fats, an undesired side effect is often:
(A) Formation of trans fatty acids
(B) Conversion of saturated fats into unsaturated fatty acid forms
(C) Hydrolysis of ester bonds which produces free fatty acid chains
(D) Polymerization of short-chain fatty acids into complex waxes

2022

110. Identify the correct combination regarding glycerophospholipids.
I. Phosphatidylcholine is a major component of the outer leaflet of plasma membranes.
II. Cardiolipin is found exclusively in the inner mitochondrial membrane.
III. Phosphatidylserine carries a net positive charge at physiological pH.
IV. Phosphatidylinositol can be phosphorylated to form PIP2.
V. They are strictly hydrophobic molecules.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and V
(C) I, III and IV
(D) I, IV and V

2006

111. The formation of mono- and diacylglycerols in the small intestine is primarily catalyzed by:
(A) Gastric pepsin
(B) Bile salts directly
(C) Lipoprotein lipase
(D) Pancreatic lipase

2002

112. Sphingomyelin serves as a major structural component in which specific biological tissue?
(A) Plant cell walls
(B) The myelin sheath of nerve cells
(C) Bacterial flagella
(D) Insect exoskeletons

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2025

113. Gangliosides differ functionally from other lipids primarily in their role as:
(A) Primary energy storage units within mammalian muscle tissue
(B) Direct precursors for the biosynthesis of steroid hormones
(C) Biological emulsifiers within the human digestive tract
(D) Cellular recognition markers and receptors on the cell surface

2021

114. Sulfoquinovosyl diacylglycerol (SQDG) is hypothesized to functionally substitute for which lipid class under phosphate-limiting conditions in plants?
(A) Sterols
(B) Triacylglycerols
(C) Sphingolipids
(D) Phospholipids

2007

115. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Cholesterol acts as a bidirectional regulator of membrane fluidity.
Reason (R): Its rigid ring system prevents tight packing of fatty acyl chains at low temperatures, while simultaneously restricting their motion at high temperatures.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

116. Primary bile acids, cholic acid and chenodeoxycholic acid, are synthesized directly from:
(A) Arachidonic acid
(B) Cholesterol
(C) Sphingomyelin
(D) Squalene

2008

117. Which structural feature characterizes the prostaglandin E (PGE) series?
(A) Beta-hydroxy ketone group on the cyclopentane ring
(B) Unmodified straight-chain hydrocarbon molecular chain
(C) Perfectly aromatic ring system within the lipid molecule
(D) Complete lack of any double bonds in the carbon skeleton

2012

118. When isolating total carbohydrates from plant tissues, ethanol is often added to the hot water extract to:
(A) Hydrolyze the polymers
(B) Dissolve the lipid contaminants completely
(C) Destroy residual enzymatic activity
(D) Precipitate the soluble polysaccharides

2021

119. Molisch test is a general qualitative test for carbohydrates. What is the active chemical intermediate that reacts with alpha-naphthol?
(A) Glucuronic acid
(B) Furfural or its derivatives
(C) Cupric oxide
(D) Enediol anions

2004

120. Determine the correct order for the systematic chemical synthesis or derivatization of FAMEs (Fatty Acid Methyl Esters) for GC.
(A) Addition of methanolic HCl/BF_3 → Heating → Cooling → Extraction with non-polar solvent (e.g., hexane)
(B) Extraction with non-polar solvent → Heating → Addition of methanolic HCl/BF_3 → Cooling
(C) Addition of methanolic HCl/BF_3 → Extraction with non-polar solvent → Heating → Cooling
(D) Heating → Addition of methanolic HCl/BF_3 → Extraction with non-polar solvent → Cooling

2023

121. The Anthrone test for carbohydrates relies on the development of which color?
(A) Brick red
(B) Purple ring
(C) Yellow to orange
(D) Blue-green

2019

122. In the Soxhlet extraction of lipids, the solvent is repeatedly:
(A) Cooled to sub-zero temperatures to precipitate all lipid classes
(B) Mixed with strong mineral acids to liberate bound lipid moieties
(C) Vaporized, condensed, and percolated through the sample

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(D) Partitioned against heavy water to separate based on density

2010

123. A high saponification number implies that the fat or oil contains a large proportion of:
(A) Very long-chain fatty acids
(B) Polyunsaturated fatty acids
(C) Free, unesterified fatty acids
(D) Short-chain fatty acids

2014

124. During gas chromatography (GC) of fatty acid methyl esters, compounds are primarily separated based on:
(A) Boiling point and affinity for the stationary phase
(B) Their net ionic charge at a specific physiological pH value
(C) Their specific rotation of plane-polarized light in solution
(D) Antigen-antibody interactions within the analytical column

2004

125. Match the glycoconjugate/polysaccharide to its biological function.
List I: (Polysaccharide)
P. Glycogen
Q. Hyaluronic acid
R. Teichoic acid
S. Chitin
List II: (Function)
1. Major structural component of the exoskeleton of arthropods
2. Regulates ion movement and provides rigidity in Gram-positive cell walls
3. Primary energy storage in mammals
4. Provides viscosity and lubrication in synovial fluid
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-4, R-2, S-3

2013

126. Why do ketoses like fructose test positive in Benedict's test despite lacking an aldehyde group?
(A) Converted to aldoses via enediol intermediates in alkali
(B) The ketone group directly reduces the copper ion in solution
(C) They are cleaved into two distinct aldehyde-containing trioses
(D) Benedict's reagent contains an acid that oxidizes the ketones

2004

127. Which form of D-fructose is the primary constituent of the disaccharide sucrose?
(A) alpha-D-fructopyranose
(B) beta-D-fructofuranose
(C) alpha-D-fructofuranose
(D) beta-D-fructopyranose

2001

128. What is the fundamental difference in the alpha and beta anomers of D-glucopyranose?
(A) The specific sequence of the carbon atoms within the chain
(B) Total number of carbon atoms found in the pyranose ring
(C) The direction they rotate plane-polarized light without exception
(D) Position of the C-1 hydroxyl relative to the ring plane

2005

129. Starch consists of amylose and amylopectin. Which statement accurately reflects their iodine-staining properties?
(A) Amylose stains red-violet, while amylopectin stains deep blue
(B) Both components stain deep blue with equal color intensity
(C) Amylose stains deep blue, amylopectin stains red-violet
(D) Neither component reacts with iodine to form colored complex

2022

130. Identify the incorrect combination regarding structural polysaccharides.
I. Cellulose chains form a flat, extended ribbon-like structure.
II. Pectin contains mainly polygalacturonic acid sequences.
III. Chitin is completely resistant to lysozyme under all conditions.
Which of the above statement(s) is/are incorrect?
(A) I and II
(B) III only
(C) II and III
(D) I only

2013

131. Which of the following mucopolysaccharides lacks an uronic acid in its repeating disaccharide unit?
(A) Heparin

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(B) Chondroitin sulfate
(C) Hyaluronic acid
(D) Keratan sulfate

2005

132. The ABO blood group specificities reside on the terminal oligosaccharides of glycosphingolipids and glycoproteins. Individuals with the O blood type produce:
(A) Anti-A and Anti-B antibodies
(B) Exclusively Anti-A antibodies
(C) Exclusively Anti-B antibodies
(D) Neither Anti-A nor Anti-B

2004

133. The lipopolysaccharide (LPS) structure includes the O-antigen, core oligosaccharide, and Lipid A. Which part determines the serological specificity of the bacteria?
(A) Lipid A region
(B) Inner core oligosaccharide
(C) O-specific polysaccharide side chain (O-antigen)
(D) The Kdo region

2009

134. Which nomenclature correctly describes stearic acid?
(A) 18:0
(B) 16:0
(C) 18:1(delta 9)
(D) 20:4(delta 5,8,11,14)

2005

135. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The melting point of saturated fatty acids increases with an increase in carbon chain length.
Reason (R): Longer hydrocarbon chains permit greater van der Waals interactions between the molecules, requiring more energy to disrupt the solid state.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2003

136. Complete hydrogenation of linoleic acid yields which saturated fatty acid?
(A) Stearic acid
(B) Palmitic acid
(C) Oleic acid
(D) Arachidic acid

2008

137. Triacylglycerols are highly efficient for energy storage because they are:
(A) Highly oxidized and heavily hydrated molecules
(B) Highly reduced and chemically unreactive structures
(C) Highly reduced, anhydrous, and densely packed
(D) Molecules that are highly soluble in the cytoplasm

2004

138. Which glycerophospholipid is unique due to its net negative charge at physiological pH and role in identifying apoptotic cells when flipped to the outer membrane leaflet?
(A) Phosphatidylcholine
(B) Phosphatidylethanolamine
(C) Phosphatidylserine
(D) Phosphatidylinositol

2005

139. In a ceramide molecule, a fatty acid is attached to the sphingosine backbone via which type of bond?
(A) Ester bond
(B) Ether bond
(C) Phosphodiester bond
(D) Amide bond

2004

140. Arrange the following steps for isolating and purifying starch from grains.
(A) Steeping in sulfurous acid → Wet milling → Screening → Centrifugation/washing → Drying
(B) Wet milling → Steeping in sulfurous acid → Centrifugation/washing → Screening → Drying
(C) Screening → Wet milling → Steeping in sulfurous acid → Drying → Centrifugation/washing
(D) Steeping in sulfurous acid → Screening → Wet milling → Drying → Centrifugation/washing

NODIA

2007

141. Sulfolipids found in chloroplasts are structurally categorized as:
(A) Sphingolipids
(B) Glyceroglycolipids
(C) Phospholipids

(D) Steryl esters

2014

142. The structural organization of aminolipids frequently involves:
(A) A long-chain amino alcohol coupled with a steroid nucleus
(B) Amino acid linked to a lipid moiety via ester/amide bonds
(C) Lipids that consist exclusively of highly branched fatty acids
(D) A glycerol backbone with three identical amino acid substituents

2017

143. Which of the following sterols is the primary precursor for Vitamin D_3 (cholecalciferol) synthesis in humans?
(A) 7-Dehydrocholesterol
(B) Ergosterol
(C) Stigmasterol
(D) Lanosterol

2021

144. Bile acids act as biological detergents primarily because they possess:
(A) Entirely non-polar multi-ring hydrocarbon structure
(B) Strong oxidative potential that breaks down fat molecules
(C) Hydrophilic alpha face and hydrophobic beta face
(D) High proportion of basic amino acids in their structure

2002

145. Identify the correct combination of statements concerning prostaglandins.
I. They are synthesized in almost all mammalian tissues.
II. Their biological half-life is typically extremely short.
III. They act as classical circulating endocrine hormones.
IV. They consist of a 20-carbon skeleton with a 5-membered ring.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I and IV

2014

146. A common technique to extract neutral lipids efficiently without degrading them involves utilizing:
(A) Boiling aqueous sodium hydroxide solutions
(B) Non-polar solvents like hexane or petroleum ether
(C) Concentrated sulfuric acid at room temperature
(D) High-molarity salt solutions for partitioning

2022

147. Which colorimetric test is best suited for the quantitative estimation of total carbohydrates in a crude plant extract without needing to distinguish between reducing and non-reducing sugars?
(A) Nelson-Somogyi method
(B) Phenol-sulfuric acid method
(C) Barfoed's test
(D) Fehling's test

2005

148. During the qualitative determination of lipids, the acid value provides an estimate of:
(A) The number of double bonds present
(B) The oxidative stability of the oil
(C) The molecular weight of the dominant triacylglycerols
(D) The degree of hydrolytic rancidity

2017

149. In the Bligh-Dyer method, adjusting the ratio of chloroform:methanol:water leads to:
(A) Biphasic separation with lipids in the lower chloroform layer
(B) The complete precipitation of all proteins and nucleic acids
(C) Biphasic separation with lipids in the upper aqueous layer
(D) The evaporation of all volatile lipids

2025

150. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Thin-Layer Chromatography (TLC) relies on both the stationary and mobile phases to separate lipid classes.
Reason (R): Non-polar lipids migrate further up the silica gel plate than polar lipids when a non-polar solvent system is used.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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2008

151. An aldohexose such as D-glucose has how many chiral centers in its open-chain form?
(A) 3
(B) 4
(C) 5
(D) 6

2006

152. Which structural feature leads to the optical activity observed in carbohydrate solutions?
(A) The presence of a carbonyl group in the molecule
(B) The ability to form ring structures in an aqueous state
(C) Presence of asymmetric (chiral) carbon atoms
(D) The lack of a plane of symmetry within the solvent used

2002

153. Trehalose consists of two molecules of glucose connected by an alpha,alpha-1,1-glycosidic bond. This structure ensures that trehalose:
(A) Is easily fermented by all available strains of yeast
(B) Rapidly forms a stable pyranose-furanose hybrid molecule
(C) Cannot be oxidized by weak oxidizing agents
(D) Will exhibit a rapid process of mutarotation in water

2005

154. Starch granules swell and form a viscous paste when heated in water, a process known as:
(A) Gelatinization
(B) Dextrinization
(C) Caramelization
(D) Retrogradation

2022

155. Match the lipid analysis method with its measured parameter.
List I: (Method)
P. Gas Chromatography (GC)
Q. Thin-Layer Chromatography (TLC)
R. Iodine value titration
S. Peroxide value titration
List II: (Parameter)
1. Separation of complex lipid mixtures into classes (e.g., phospholipids vs neutral lipids)
2. Identification and quantification of individual fatty acid profiles
3. Measurement of the milliequivalents of active oxygen (hydroperoxides)
4. Determination of the overall degree of unsaturation via halogenation
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-1, Q-4, R-2, S-3

2010

156. Cellulose and amylose are both linear homopolysaccharides of D-glucose. The critical difference defining their macroscopic physical properties is:
(A) Amylose is alpha-1,4 helical; cellulose is beta-1,4 rigid chains
(B) Amylose contains branched points, while cellulose does not
(C) Cellulose is modified with various types of sulfate groups
(D) Amylose is much larger in molecular weight than cellulose

2024

157. Which enzyme is responsible for the degradation of hyaluronic acid in biological tissues?
(A) Hyaluronidase
(B) Chondroitinase
(C) Beta-glucuronidase
(D) Lysozyme

2003

158. The specific structure of the H antigen (the foundation for A and B antigens) terminates with:
(A) Alpha-L-fucose linked to a galactose residue
(B) Beta-D-galactose linked to an N-acetylglucosamine unit
(C) Alpha-D-mannose linked directly to a ceramide backbone
(D) Sialic acid residues linked specifically to a lactose unit

2002

159. Gram-positive bacteria lack which of the following structures characteristic of Gram-negative bacteria?
(A) A thick peptidoglycan layer
(B) Various types of teichoic acids
(C) Outer lipid membrane containing LPS
(D) A standard plasma membrane

2002

160. Identify the incorrect combination regarding fatty acid nomenclature.
I. 18:3(omega-3) is alpha-linolenic acid.
II. 20:4(omega-6) is arachidonic acid.
III. 18:1(omega-9) is oleic acid.
IV. 16:0 is stearic acid.

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Which of the above statements is incorrect?
(A) I and II
(B) IV only
(C) III and IV
(D) II only

2014

161. A trans fatty acid typically mimics the physical properties of a saturated fatty acid because:
(A) It lacks double bonds entirely in its hydrocarbon chain
(B) Linear chain conformation allowing tight packing
(C) It becomes completely water-soluble in biological fluids
(D) The double bond naturally shifts to terminal methyl group

2015

162. Oxidative rancidity in fats is primarily initiated by:
(A) Hydrolysis of ester bonds by ubiquitous cellular lipases
(B) Microbial fermentation occurring on the glycerol backbone
(C) Autoxidation of unsaturated fatty acids by free radicals
(D) Thermal breakdown of saturated bonds during deep frying

2016

163. Diacylglycerol (DAG) activates which crucial regulatory enzyme in the phosphoinositide cascade?
(A) Protein Kinase A
(B) Phospholipase C
(C) Protein Kinase C
(D) Adenylyl cyclase

2024

164. What causes the spontaneous self-assembly of glycerophospholipids into lipid bilayers in an aqueous environment?
(A) Covalent bonds forming between adjacent phosphate groups
(B) Amphipathic nature driving the hydrophobic effect
(C) Presence of integral membrane proteins bridging molecules
(D) Extensive hydrogen bonding patterns among the acyl chains

2010

165. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.

Assertion (A): Tay-Sachs disease is characterized by a massive accumulation of ganglioside GM2 in the brain.
Reason (R): It is caused by a genetic deficiency of the lysosomal enzyme hexosaminidase A.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

166. Cerebrosides differ from classical membrane phospholipids because they:
(A) Have a sphingosine backbone and lack a phosphate group
(B) Have a glycerol backbone and a single sulfate group
(C) Are lipids that are entirely non-polar in nature
(D) Are molecules that cannot be degraded by enzymes

2019

167. Chloroplast sulfolipids (SQDG) play an important role in the thylakoid membrane primarily to:
(A) Act as the main light-harvesting pigment in the system
(B) Maintain membrane functionality under phosphate deficiency
(C) Store sulfur for the synthesis of essential amino acids
(D) Provide extreme rigidity to prevent unwanted membrane fusion

2015

168. The basic skeleton of all steroid molecules, including cholesterol, consists of:
(A) A 17-carbon polycyclic structure
(B) A 20-carbon arachidonate derivative
(C) A straight-chain 30-carbon molecule
(D) A 15-carbon farnesyl pyrophosphate chain

2008

169. Bile acids differ from cholesterol in that bile acids:
(A) Have more hydroxyls and a shortened, carboxylated side chain
(B) They completely lack the characteristic steroid nucleus
(C) They are characterized as being completely hydrophobic
(D) They are fundamentally incapable of forming

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micelles

2017

170. Identify the correct combination regarding eicosanoids.

I. Thromboxanes contain a 6-membered oxane ring.
II. Prostaglandins are classical examples of endocrine hormones.
III. Leukotrienes contain three conjugated double bonds and lack a ring structure.
IV. NSAIDs like aspirin block the lipoxygenase pathway.

Which of the above statements is correct?
(A) I and III
(B) II and IV
(C) I, III and IV
(D) I only

2021

171. Why is the Folch extraction method superior for extracting total lipids from brain tissue compared to a simple hexane extraction?
(A) Disrupts protein-lipid interactions and extracts polar lipids
(B) Brain tissue consists of neutral lipids which dissolve faster
(C) Hexane degrades delicate brain sphingolipids instantly
(D) Folch extraction specifically precipitates all sterol classes

2007

172. The presence of reducing sugars in a biological sample can be semi-quantitatively assessed using Benedict's reagent. The resulting color shift from blue to brick-red is due to:
(A) The oxidation of cupric ions to cuprous ions
(B) The formation of a cupric-hydroxide complex
(C) The binding of copper to the enediol double bond
(D) The precipitation of cuprous oxide (Cu2O)

2008

173. The principle of the phenol-sulfuric acid method is based on the dehydration of sugars to form furfural derivatives. Which acid is responsible for this dehydration step?
(A) Concentrated sulfuric acid
(B) Phenol
(C) Hydrochloric acid
(D) Phosphoric acid

2015

174. Which of the following best describes the principle of determining the peroxide value of a fat?
(A) Measuring the absorbance of ultraviolet light by dienes
(B) Titrating the fat with potassium hydroxide for acid content
(C) Liberation of iodine from KI by lipid hydroperoxides
(D) Reacting the lipid sample with Wijs halogenating reagent

2005

175. Gas chromatography analyzes FAMEs based on their differential partitioning between a mobile gas phase and a stationary liquid phase. What is the standard detector used for FAME analysis?
(A) UV-Vis Spectrophotometer
(B) Flame Ionization Detector (FID)
(C) Evaporative Light Scattering Detector (ELSD)
(D) Refractive Index Detector (RID)

2005

176. Which configuration characterizes the alpha-anomer of D-glucopyranose according to the standard Haworth projection?
(A) The hydroxyl group at C-1 is drawn above the plane of the ring
(B) The hydroxyl group at C-2 is axial
(C) The hydroxyl group at C-1 is drawn below the plane of the ring
(D) The ring oxygen is positioned at the bottom left

2009

177. A racemic mixture of enantiomers exhibits what type of optical activity?
(A) Zero optical rotation
(B) Strongly dextrorotatory
(C) Strongly levorotatory
(D) Variable optical rotation depending on temperature alone

2007

178. What linkage connects the two glucose units in cellobiose, a partial hydrolysis product of cellulose?
(A) alpha-1,4 glycosidic bond
(B) alpha-1,6 glycosidic bond
(C) beta-1,6 glycosidic bond
(D) beta-1,4 glycosidic bond

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2017

179. Branching in glycogen occurs approximately every:
(A) 4 to 6 residues
(B) 8 to 12 residues
(C) 24 to 30 residues
(D) 50 to 60 residues

2001

180. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Pectinases are widely used in the fruit juice industry.
Reason (R): Pectin forms a gel-like network that traps liquid and causes cloudiness; pectinases break this network down, clarifying the juice.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022

181. Which glycosaminoglycan is the most abundant in the human body, particularly forming a major component of cartilage?
(A) Chondroitin sulfate
(B) Heparin
(C) Hyaluronic acid
(D) Keratan sulfate

2014

182. The addition of the terminal sugar to the H-antigen to form the A or B blood group antigen is catalyzed by highly specific:
(A) Glycosidases
(B) Glycosyltransferases
(C) Phospholipases
(D) Peptidases

2015

183. Peptidoglycan integrity is crucial for bacterial survival. Lysozyme acts as an antibacterial agent by cleaving the:
(A) Peptide cross-links between the muramic acid residues
(B) Beta-1,4 glycosidic bond between GlcNAc and MurNAc
(C) Ester bonds linking teichoic acid to the membrane layers
(D) The outer lipopolysaccharide layer found in some bacteria

2019

184. Linoleic and alpha-linolenic acids are essential for mammals because mammalian cells lack the desaturase enzymes capable of introducing double bonds beyond which carbon atom (counting from the carboxyl end)?
(A) Carbon 9
(B) Carbon 12
(C) Carbon 15
(D) Carbon 6

2016

185. Match the lipid to its fundamental structural class.
List I: (Lipid)
P. Ceramide
Q. Phosphatidylcholine
R. Cholic acid
S. Thromboxane
List II: (Structural Class)
1. Glycerophospholipid
2. Eicosanoid
3. Sphingolipid
4. Sterol derivative
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-3, S-2

2004

186. Which structural parameter primarily influences the saponification value of a fat?
(A) Average molecular weight (chain length) of fatty acids
(B) The specific number of cis double bonds in the chains
(C) The presence of naturally occurring sterol contaminants
(D) The specific position of the double bonds in the molecule

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2014

187. Monoacylglycerols are structurally composed of:
(A) One glycerol molecule and one fatty acid esterified to it
(B) One glycerol molecule and one phosphate group
(C) One fatty acid and one sphingosine backbone
(D) One glycerol molecule linked to a sterol

2004

188. In biological membranes, the fluidity is increased by:
(A) Increasing the proportion of saturated fatty acid chains
(B) Decreasing the ambient temperature of the

environment
(C) Increasing the proportion of cis-unsaturated fatty acids
(D) Increasing the total length of the fatty acyl chains

2012

189. Niemann-Pick disease is associated with the dangerous cellular accumulation of:
(A) Glucocerebroside
(B) Ganglioside GM2
(C) Sphingomyelin
(D) Ceramide

2001

190. Identify the incorrect combination concerning glycolipids.
I. Cerebrosides contain a single sugar residue linked to ceramide.
II. Gangliosides contain complex oligosaccharides but lack sialic acid.
III. Globosides contain two or more sugars and no sialic acid.
Which of the above statements is incorrect?
(A) I and III
(B) II only
(C) I, II and III
(D) III only

2024

191. The synthesis of primary bile acids is strictly regulated by the action of which rate-limiting enzyme?
(A) Cholesterol 7-alpha-hydroxylase
(B) HMG-CoA reductase
(C) Cyclooxygenase
(D) Phospholipase A_2

2010

192. Which drug class functions by irreversibly inhibiting cyclooxygenase (COX), thereby reducing prostaglandin and thromboxane synthesis?
(A) Blocking the release of arachidonic acid from membranes
(B) Inhibiting the HMG-CoA reductase enzyme in cholesterol
(C) Non-steroidal anti-inflammatory drugs (NSAIDs)
(D) Blocking the action of specific beta-adrenergic receptors

2022

193. Extraction of soluble sugars from plant tissues often employs 80% ethanol primarily to:
(A) Solubilize the various types of structural polysaccharides
(B) Extract low-MW sugars; precipitate proteins/polysaccharides
(C) Hydrolyze the starch polymers directly into glucose units
(D) Completely remove all cellular water from the plant tissue

2012

194. In the Nelson-Somogyi method for reducing sugars, what is the role of the arsenomolybdate reagent?
(A) It directly reduces the sugar molecules in the solution
(B) Forms a stable molybdenum blue complex with Cu2O
(C) It acts as a buffer to maintain a specific alkaline pH
(D) It stops the reaction by neutralizing the acid components

2005

195. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The acid value of a refined cooking oil should ideally be very low.
Reason (R): A low acid value indicates minimal hydrolysis of triglycerides into free fatty acids.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

196. Thin-layer chromatography separates lipids predominantly based on:
(A) Polarity differences and silica gel interactions
(B) Strict molecular weight sizing like a gel filtration column
(C) Focuses on the isoelectric point of various lipid classes
(D) Separation based on antigenic specificity of head groups

2007

197. Epimerization of D-glucose at the C-4 position yields:
(A) D-mannose
(B) D-galactose
(C) D-fructose
(D) D-allose

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2005

198. The rotation of plane-polarized light by a carbohydrate solution is measured using a:
(A) Spectrophotometer
(B) Fluorometer
(C) Polarimeter
(D) Refractometer

2024

199. Maltose is produced biologically by the enzymatic breakdown of:
(A) Cellulose
(B) Chitin
(C) Starch
(D) Glycogen strictly in the liver

2009

200. Identify the correct combination of properties for glycogen.
I. It is stored mainly in the liver and skeletal muscle.
II. It is less branched than amylopectin.
III. It yields a red-violet color with iodine.
IV. Its degradation is catalyzed by glycogen phosphorylase.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I and IV

2005

201. Which specific intramolecular bonds maintain the rigid, extended structure of the cellulose polymer?
(A) Ester bonds between the glucose monomers in the chain
(B) Intramolecular hydrogen bonds between adjacent units
(C) Disulfide bonds within the structural framework of unit
(D) Phosphodiester bonds connecting the adjacent sugar rings

2021

202. Heparin prevents blood coagulation by greatly enhancing the activity of which natural inhibitor?
(A) Plasminogen
(B) Antithrombin III
(C) Fibrinogen
(D) Prothrombin

2009

203. The specificity of the ABO blood groups is based on:
(A) Variations in the lipid tail of the membrane anchor region
(B) Sequence and terminal sugar of the oligosaccharide
(C) The amino acid sequence of integral membrane proteins
(D) Presence of specific teichoic acids on the cell surface

2012

204. The toxic component of Gram-negative bacterial lipopolysaccharide, responsible for endotoxic shock, is:
(A) The O-specific chain
(B) The core oligosaccharide
(C) Lipid A
(D) Peptidoglycan

2010

205. Match the specific linkage to the appropriate disaccharide/polysaccharide.
List I: (Linkage)
P. alpha-1,2
Q. beta-1,4
R. alpha-1,4
S. alpha-1,6
List II: (Saccharide)
1. Cellulose backbone
2. Sucrose
3. Maltose backbone
4. Branch point in amylopectin
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-3, R-1, S-4

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2024

206. Omega-6 fatty acids are derived primarily from which essential fatty acid precursor?
(A) alpha-Linolenic acid
(B) Linoleic acid
(C) Oleic acid
(D) Palmitoleic acid

2016

207. Hydrogenation of oils not only raises the melting point but also prevents:
(A) Enzymatic hydrolysis by lipases
(B) Autoxidation and development of rancidity
(C) The separation of free fatty acids
(D) The formation of trans double bonds

2013

208. During the digestion of dietary triacylglycerols, pancreatic lipase specifically cleaves the fatty acids at which positions?
(A) sn-2 position only

(B) sn-1 and sn-3 positions
(C) All three positions simultaneously
(D) sn-1 position only

2003

209. The head group of phosphatidylcholine is attached to the glycerol-phosphate backbone via an ester linkage to the phosphate. Choline carries a:
(A) Permanent negative charge on the head group molecule
(B) Permanent positive charge (quaternary ammonium group)
(C) Zwitterionic state capable of being neutralized in solution
(D) Completely uncharged and hydrophobic character of head

2021

210. Identify the incorrect combination concerning sphingolipids.
I. They lack a glycerol backbone.
II. Sphingomyelin contains a phosphate group.
III. Ceramides consist of sphingosine and a fatty acid.
IV. Cerebrosides contain a complex highly branched oligosaccharide.
Which of the above statement(s) is/are incorrect?
(A) I and II
(B) IV only
(C) III and IV
(D) II only

2004

211. Which property distinguishes gangliosides from globosides?
(A) Gangliosides are found exclusively within plant tissues
(B) Contain one or more sialic acid residues
(C) Gangliosides utilize a glycerol-based structural backbone
(D) Gangliosides lack a characteristic amide bond in base

2003

212. In plant leaves under severe phosphate starvation, which lipid class dramatically increases to compensate for the loss of phospholipids?
(A) Sphingolipids
(B) Galactolipids and Sulfolipids (SQDG)
(C) Sterols
(D) Triacylglycerols

2010

213. Sterols are synthesized biologically from two-carbon units via the isoprenoid pathway. The immediate linear precursor that cyclizes to form the sterol ring system is:
(A) Isopentenyl pyrophosphate
(B) Squalene
(C) Farnesyl pyrophosphate
(D) Lanosterol

2010

214. Secondary bile acids like deoxycholic acid and lithocholic acid are produced in the colon by:
(A) Dehydroxylation of primary bile acids by bacteria
(B) Oxidation of cholesterol molecules by local colonocytes
(C) Deconjugation of taurine residues by host tissue enzymes
(D) Rapid polymerization occurring among unabsorbed lipids

2010

215. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Prostaglandins usually act locally near their site of synthesis (paracrine/autocrine action).
Reason (R): They are chemically unstable and rapidly deactivated by enzymes in the circulation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

216. In the quantitative analysis of carbohydrates, which method utilizes a concentrated acid to hydrolyze and dehydrate polysaccharides directly into furfural derivatives without prior hydrolysis?
(A) Phenol-sulfuric acid method
(B) Nelson-Somogyi method
(C) Barfoed's test
(D) Fehling's test

2025

217. When performing qualitative analysis, the appearance of a cherry-red color in Seliwanoff's test within 1-2 minutes typically confirms the presence of:
(A) An aldohexose
(B) A ketohexose like fructose
(C) An aldopentose
(D) A complex polysaccharide

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2001

218. The iodine value of coconut oil is typically very low (around 7-10). This implies that coconut oil:
(A) Predominantly composed of saturated fatty acids
(B) Highly susceptible to the process of oxidative rancidity
(C) Contains very long-chain fatty acids in its composition
(D) Has a high proportion of free fatty acid content in it

2006

219. During lipid extraction by the Bligh-Dyer method, the ratio of chloroform, methanol, and water must be carefully controlled to:
(A) Ensure that the lipids precipitate cleanly from the mix
(B) Prevent the solvent system from catching fire during use
(C) Achieve optimal biphasic system separation
(D) Hydrolyze the triglycerides into free fatty acid chains

2006

220. Identify the correct combination regarding GC of fatty acids.
I. Lipids must first be derivatized into FAMEs to increase volatility.
II. A flame ionization detector (FID) is commonly used.
III. Retention time is independent of carbon chain length.
IV. Capillary columns coated with a polar or non-polar stationary phase are used.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I and II

2009

221. Which monosaccharide is a C-2 epimer of D-glucose?
(A) D-Mannose
(B) D-Galactose
(C) D-Fructose
(D) D-Ribose

2021

222. The standard physiological form of glucose in the human bloodstream is:
(A) L-glucopyranose
(B) D-glucopyranose
(C) D-glucofuranose
(D) L-glucofuranose

2002

223. The non-reducing nature of sucrose dictates that it will:
(A) Fail to exhibit mutarotation in aqueous solution
(B) Test positive in Benedict's test without prior hydrolysis
(C) Rapidly polymerize into dextrans
(D) Bind copper permanently

2021

224. Which structural feature characterizes the unique non-reducing disaccharide trehalose?
(A) An alpha,beta-1,2 linkage
(B) An alpha,alpha-1,1 linkage between two glucose molecules
(C) A beta,beta-1,4 linkage between two glucose molecules
(D) A beta,alpha-1,2 linkage between galactose and glucose

2018

225. Match the polysaccharide to its defining chemical linkage.
List I: (Polysaccharide)
P. Amylose
Q. Cellulose
R. Chitin
S. Amylopectin branches
List II: (Linkage)
1. beta-1,4 (N-acetylglucosamine)
2. alpha-1,4 (glucose)
3. beta-1,4 (glucose)
4. alpha-1,6 (glucose)
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-1, Q-4, R-2, S-3
(D) P-2, Q-1, R-3, S-4

2012

226. What makes the physical structure of glycogen more compact and soluble than amylopectin?
(A) Shorter chains and a higher degree of branching
(B) Specific presence of unbranched helical structures
(C) Incorporation of beta linkages into the glucose chain
(D) Covalent bonding with structural protein complexes

2019

227. Which acid is a key component of the repeating disaccharide in hyaluronic acid?
(A) Glucuronic acid
(B) Iduronic acid

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(C) Galacturonic acid
(D) Sialic acid

2024

228. Which component is responsible for the massive antigenic diversity of the bacterial lipopolysaccharide (LPS)?
(A) The highly variable O-antigen chain
(B) Lipid A
(C) The inner core region
(D) Teichoic acid polymers

2011

229. A typical naturally occurring unsaturated fatty acid contains double bonds predominantly in which geometric configuration?
(A) Cis configuration
(B) Trans configuration
(C) Alternating cis and trans
(D) Conjugated straight chains

2024

230. Identify the incorrect combination concerning lipid properties.
I. The melting point of saturated fatty acids decreases as chain length increases.
II. Unsaturated fatty acids are more prone to autoxidation than saturated ones.
III. Trans fatty acids pack more tightly than cis fatty acids.
Which of the above statements is incorrect?
(A) I and II
(B) II and III
(C) I only
(D) III only

2014

231. The primary structural advantage of storing metabolic energy as triacylglycerols instead of glycogen is:
(A) Twice the energy per gram and require no hydration
(B) Triacylglycerols can be metabolized under anaerobic states
(C) Triacylglycerols are readily soluble in blood plasma
(D) Triacylglycerols are easily converted to glucose in humans

2003

232. Phosphatidylinositol 4,5-bisphosphate (PIP2) is cleaved by Phospholipase C to generate which two intracellular secondary messengers?
(A) IP3 and Diacylglycerol (DAG)
(B) cAMP and cGMP molecules used for cellular signaling
(C) Ceramide and Sphingosine-1-phosphate signaling lipids
(D) Arachidonic acid and Lysophosphatidic acid molecules

2002

233. The sphingosine backbone is synthesized in cells from which two precursors?
(A) Palmitoyl-CoA and Serine
(B) Acetyl-CoA and Glycine
(C) Malonyl-CoA and Choline
(D) Arachidonyl-CoA and Ethanolamine

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2022

234. In plant chloroplasts, galactolipids dominate over phospholipids. The most abundant of these is:
(A) Monogalactosyldiacylglycerol (MGDG)
(B) Digalactosylceramide
(C) Sulfoquinovosyldiacylglycerol
(D) Phosphatidylglycerol

2019

235. The fundamental repeating unit for the synthesis of all sterols via the mevalonate pathway is:
(A) The five-carbon isoprene unit (IPP)
(B) The two-carbon acetyl unit
(C) The three-carbon malonyl unit
(D) The six-carbon glucose unit

2016

236. Bile salts are essentially bile acids that have been conjugated. This conjugation primarily occurs with:
(A) Glycine or taurine
(B) Glucuronic acid or sulfate
(C) Choline or ethanolamine
(D) Acetyl-CoA or Malonyl-CoA

2003

237. Prostaglandin synthesis is initiated by the release of arachidonic acid from membrane phospholipids, an action primarily catalyzed by:
(A) Phospholipase A_2
(B) Phospholipase C
(C) Phospholipase D
(D) Lipoprotein lipase

2001

238. For the extraction of low-molecular-weight sugars (like sucrose and fructose) from plant materials, which solvent is generally preferred to minimize the extraction of large polysaccharides?
(A) Hot 80% aqueous ethanol
(B) Absolute chloroform
(C) Cold distilled water
(D) Concentrated hydrochloric acid

2015

239. The Seliwanoff's test distinguishes ketoses from aldoses based on the fact that ketoses:
(A) Undergo dehydration to furfurals more rapidly than aldoses
(B) Do not react with the resorcinol reagent at any point
(C) Contain significantly fewer carbon atoms than aldoses
(D) Form entirely different intermediate compounds lacking rings

2017

240. Identify the correct combination of quantitative lipid assays.
I. Peroxide value determines the degree of primary oxidation.
II. Iodine value requires the addition of Wijs or Hanus reagent to measure unsaturation.
III. Acid value measures the free fatty acid content indicating hydrolytic rancidity.
IV. Saponification value indicates the average molecular weight of the fatty acids.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I, II, III and IV

2010

241. What is the fundamental principle of visualizing lipid spots on a TLC plate using iodine vapor?
(A) Iodine partitions reversibly into hydrophobic lipid spots
(B) Iodine reacts irreversibly with free hydroxyl groups
(C) Iodine causes immediate oxidative cleavage of all bonds
(D) Iodine fluoresces brightly under ultraviolet light sources

2007

242. In gas chromatography of FAMEs, a column with a highly polar stationary phase will generally elute unsaturated fatty acids:
(A) Slower than saturated fatty acids of the same length
(B) Faster than saturated fatty acids of the same length
(C) At the exact same time as the saturated fatty acids
(D) Without any dependence on the total carbon chain length

2024

243. During mutarotation, the specific rotation of alpha-D-glucose and beta-D-glucose in solution eventually reaches an equilibrium value of roughly +52.7 degrees. This mixture consists predominantly of:
(A) ~ 64% beta-anomer and ~ 36% alpha-anomer
(B) ~64% alpha-anomer and ~36% beta-anomer
(C) 50% alpha and 50% beta anomers
(D) 100% open-chain form

2011

244. Diastereomers that differ in their configuration at only one chiral center are termed:
(A) Epimers
(B) Enantiomers
(C) Anomers
(D) Conformers

2016

245. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Cellulose cannot be digested by humans to yield glucose for energy.
Reason (R): Humans lack the enzyme cellulase required to break the beta-1,4 glycosidic linkages found in cellulose.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

246. The storage polysaccharide found in mammalian liver and muscle is glycogen. It structurally resembles amylopectin but is:
(A) Highly branched, with branches every 8-12 residues
(B) Completely linear in its structural arrangement
(C) Composed of fructose monomers rather than glucose
(D) Bound together by beta-1,6 glycosidic linkages

2022

247. The high tensile strength of chitin in arthropod exoskeletons is due to:
(A) Hydrogen bonding between parallel beta-1,4-linked chains
(B) Covalent cross-linking occurring with heavy metal ions

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(C) Numerous sulfate groups causing electrostatic repulsion
(D) Its helical secondary structure in its physical state

2023

248. The primary repeating disaccharide of chondroitin sulfate consists of:
(A) Glucuronic acid and N-acetylgalactosamine-sulfate
(B) Glucuronic acid and N-acetylglucosamine sugar units
(C) Iduronic acid and galactosamine in the repeating unit
(D) Galactose and glucosamine-sulfate connected together

2021

249. Blood group O individuals possess the universal 'H antigen' on their erythrocyte surfaces. The H antigen acts as:
(A) Direct precursor for A and B immunodominant sugars
(B) A strong trigger for the formation of anti-A antibodies
(C) A competitive inhibitor for all glycosyltransferase enzymes
(D) A lipid anchor independent of any saccharide chain

2017

250. Identify the incorrect combination concerning bacterial polysaccharides.
I. Peptidoglycan is absent in Gram-positive bacteria.
II. Teichoic acids are linked to peptidoglycan in Gram-positive cell walls.
III. Lipopolysaccharides (LPS) are exclusively found in Gram-negative bacteria.
Which of the above statement(s) is/are incorrect?
(A) I and II
(B) II only
(C) I only
(D) III only

2014

251. Essential fatty acids, linoleic and alpha-linolenic acids, are characterized by:
(A) First double bonds at omega-6 and omega-3 positions
(B) Having exclusively trans double bonds in their structure
(C) Being entirely saturated, medium-chain fatty acid forms
(D) Being synthesized de novo within the human liver tissue

2017

252. As the degree of unsaturation in a fatty acid increases, its susceptibility to autoxidation:
(A) Increases due to reactive allylic carbons
(B) Decreases proportionally with more double bonds
(C) Remains completely unchanged by degree of saturation
(D) Results in immediate multiplication into solid plastic

2001

253. Mono- and diacylglycerols are frequently utilized in the food industry primarily as:
(A) Emulsifying agents to stabilize oil-in-water mixtures
(B) Intense sweeteners used in the production of candy
(C) Anti-caking agents used for dry food powder products
(D) High-temperature frying oils used in food processing

2017

254. Which feature is unique to cardiolipin (diphosphatidylglycerol) among the common glycerophospholipids?
(A) Two phosphate groups and four fatty acyl chains
(B) It contains a characteristic sphingosine backbone base
(C) It is categorized as being entirely water soluble
(D) It carries a net positive charge at a pH value of 7

2012

255. Match the sphingolipid class to its key structural component.
List I: (Sphingolipid)
P. Ceramide
Q. Sphingomyelin
R. Cerebroside
S. Ganglioside
List II: (Component)
1. Contains a complex oligosaccharide with sialic acid
2. Contains a single monosaccharide (usually glucose or galactose)
3. Consists solely of sphingosine and a fatty acid
4. Contains a phosphocholine head group
(A) P-1, Q-4, R-2, S-3

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(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

2003

256. The pathological accumulation of glucocerebrosides in macrophages (Gaucher cells) is indicative of:
(A) Gaucher disease
(B) Tay-Sachs disease
(C) Farber disease
(D) Niemann-Pick disease

2005

257. Sulfolipids like SQDG are deeply involved in photosynthesis. Structurally, the sulfoquinovose sugar is linked to the diacylglycerol backbone via:
(A) An alpha-glycosidic bond
(B) A beta-glycosidic bond
(C) A phosphodiester bond
(D) A direct carbon-carbon bond

2001

258. Plant phytosterols, such as sitosterol, are known to lower human serum cholesterol levels by:
(A) Competing with dietary cholesterol for intestinal absorption
(B) Directly inhibiting HMG-CoA reductase in the cells
(C) Destroying cholesterol molecules in the bloodstream
(D) Increasing the secretion of primary bile acid molecules

2011

259. What structural modification distinguishes secondary bile acids from primary bile acids?
(A) Lack a C-7 hydroxyl due to bacterial dehydroxylation
(B) They possess additional double bonds in ring structure
(C) They are characterized as being completely un-conjugated
(D) They contain a sulfate group instead of carboxyl group

2019

260. Identify the correct combination regarding the cyclooxygenase (COX) pathway.
I. It converts arachidonic acid into prostaglandin H2.
II. It is the target of NSAIDs like ibuprofen.
III. It produces leukotrienes.
IV. It involves both oxygenase and peroxidase activities.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III and IV
(C) II, III and IV
(D) I and II

2010

261. To selectively isolate neutral lipids from a complex mixture containing polar membrane lipids, one would primarily use:
(A) TLC or solid-phase extraction using non-polar solvents
(B) HPLC using a standard C18 analytical column
(C) Boiling sample in strong aqueous alkali solution
(D) Precipitation using various types of heavy metal ions

2025

262. In the Anthrone method for carbohydrate determination, the green colored complex is measured spectrophotometrically at approximately:
(A) 620 nm
(B) 280 nm
(C) 420 nm
(D) 750 nm

2016

263. A lipid extract displaying a high iodine value but a low acid value is indicative of a fat that is:
(A) Highly unsaturated and largely intact (not hydrolyzed)
(B) Highly saturated and heavily degraded in its structure
(C) Fully hydrogenated and extensively oxidized in its form
(D) Composed almost entirely of free fatty acid chains

2001

264. To analyze the individual fatty acid composition of a triglyceride sample using GC, the triglycerides are first converted to FAMEs. This transesterification process requires:
(A) Methanol and an acid or base catalyst
(B) Ethanol and strong heat only
(C) Water and concentrated sulfuric acid
(D) Hexane and iodine

2023

265. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Amylose forms a helical secondary

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structure in water that allows it to trap iodine molecules.

Reason (R): The alpha-1,4 linkages between D-glucose monomers cause the linear chain to naturally curve and form a hollow helix.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

266. Which type of isomerism is depicted when two monosaccharides differ only in the spatial arrangement around the newly formed hemiacetal carbon?
(A) Anomerism
(B) Epimerism
(C) Enantiomerism
(D) Structural isomerism

2022

267. The non-reducing end of a glycogen molecule is characterized by:
(A) Glucose unit with a free C-4 hydroxyl group
(B) Presence of a free anomeric carbon in the sugar
(C) A phosphate group capping the end of the chain
(D) A fructose residue preventing any further elongation

2016

268. Which specific bond is responsible for the extensive branching seen in the amylopectin molecule?
(A) alpha-1,6 glycosidic bond
(B) alpha-1,4 glycosidic bond
(C) beta-1,4 glycosidic bond
(D) beta-1,6 glycosidic bond

2021

269. The rigid cell wall structure of plants is primarily composed of:
(A) Cellulose microfibrils in a hemicellulose/pectin matrix
(B) Primarily chitin and various peptidoglycan layers
(C) Solid masses of cross-linked glycogen molecules
(D) Extensive networks consisting of teichoic acids

2022

270. Identify the incorrect combination regarding glycosaminoglycans (mucopolysaccharides).
I. They are typically short, branched polymers.
II. They contain a high density of negatively charged groups.
III. Hyaluronic acid is unsulfated.
IV. Heparin is an intracellular component of mast cells.
Which of the above statements is incorrect?
(A) I only
(B) II and III
(C) I and IV
(D) III only

2010

271. Antigenic determinants for the ABO blood groups are characterized structurally as:
(A) Terminal carbohydrate sequences on membrane lipids/proteins
(B) Specific sequences of amino acids on cell surface proteins
(C) Unique configurations of cholesterol in the membrane
(D) Soluble nucleic acid fragments bound to the membrane

2018

272. In Gram-positive bacteria, teichoic acids contribute to cell wall function by:
(A) Providing negative charge and regulating cation movement
(B) Forming a thick, impermeable wax layer in the cell
(C) Anchoring flagella directly to the nuclear region
(D) Storing excess carbon as polyhydroxybutyrate units

NODIA

2008

273. The systematic name for the omega-3 fatty acid DHA (docosahexaenoic acid) indicates that it possesses:
(A) 22 carbons and 6 double bonds
(B) 20 carbons and 4 double bonds
(C) 18 carbons and 3 double bonds
(D) 24 carbons and 5 double bonds

2017

274. Why do cis-unsaturated fatty acids disrupt the close packing of lipid bilayers?
(A) Double bond kink disrupts hydrocarbon chain packing
(B) Rigid linear structure that prevents flexibility
(C) Highly polar and attract water into the lipid core

(D) Naturally cyclize to form sterol-like ring structures

2016

275. Match the correct structural feature or test to the carbohydrate.

List I: (Carbohydrate)

P. Fructose

Q. Glycogen

R. Peptidoglycan

S. Trehalose

List II: (Feature/Test)

1. Forms a red-violet complex with iodine
2. Seliwanoff's test positive (rapid cherry-red)
3. Contains N-acetylmuramic acid
4. Non-reducing sugar linking two alpha-glucose units

(A) P-2, Q-1, R-3, S-4

(B) P-1, Q-2, R-4, S-3

(C) P-2, Q-3, R-1, S-4

(D) P-3, Q-1, R-2, S-4

2012

276. The process of esterification in the synthesis of triacylglycerols involves the reaction between:

(A) Carboxyl groups of fatty acids and hydroxyls of glycerol

(B) Hydroxyl groups of fatty acids and carboxyls of glycerol

(C) Three free fatty acids condensing with each other

(D) Fatty acids reacting directly with a phosphate group

2012

277. Phosphatidylethanolamine is also known commonly as:

(A) Cephalin

(B) Lecithin

(C) Cardiolipin

(D) Plasmalogen

2019

278. Which statement regarding the sphingosine backbone is true?

(A) It contains an amino group at C-2 and a long unsaturated chain

(B) It contains a strictly saturated 16-carbon chain

(C) It is a derivative of the glycerol-based molecule

(D) It lacks any hydroxyl groups in its carbon chain

2022

279. The unique structure of cerebrosides includes:

(A) Monosaccharide beta-glycosidically linked to ceramide

(B) Phosphate group linking sugar to ceramide

(C) Monosaccharide directly linked to ceramide via ester bond

(D) Two distinct fatty acid chains attached to sugar

2002

280. Identify the correct combination of statements concerning aminolipids.

I. They contain an amino group but no phosphate group.

II. Ornithine lipids are common in bacteria grown under phosphate limitation.

III. They lack amphipathic properties entirely.

Which of the above statements are correct?

(A) I and II

(B) II and III

(C) I and III

(D) I only

2007

281. The classic steroid nucleus consists of:

(A) Three fused cyclohexane rings and one cyclopentane ring

(B) Four fused cyclopentane rings

(C) Three fused cyclopentane rings and one cyclohexane ring

(D) Two fused cyclohexane rings and an attached aliphatic chain

2023

282. Which of the following is the major primary bile acid synthesized in the human liver?

(A) Cholic acid

(B) Deoxycholic acid

(C) Lithocholic acid

(D) Ursodeoxycholic acid

2022

283. Prostaglandins act primarily as:

(A) Potent, short-lived local mediators

(B) Long-lasting endocrine hormones in circulation

(C) Structural components of mitochondrial matrix

(D) Major energy storage molecules in adipose tissue

2010

284. When extracting lipids with the Soxhlet apparatus, the typical solvent used is:

(A) A non-polar solvent like petroleum ether or hexane

(B) Concentrated sulfuric acid

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(C) Methanol and water
(D) Hot alkaline water

2001

285. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The Nelson-Somogyi method is specific for measuring reducing sugars.
Reason (R): Non-reducing sugars lack a free aldehyde or ketone group to reduce the cupric ions to cuprous oxide.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

286. What is the fundamental property of a lipid sample that determines its saponification number?
(A) Inverse relationship to average fatty acid MW
(B) Number of double bonds in hydrocarbon chains
(C) Resistance to process of autoxidation reactions
(D) Amount of naturally occurring sterols present

2024

287. In thin-layer chromatography (TLC) utilizing silica gel, which lipid class will exhibit the lowest Rf value (migrate the shortest distance) in a standard non-polar solvent system (e.g., hexane/diethyl ether/acetic acid)?
(A) Phosphatidylcholine
(B) Triacylglycerols
(C) Cholesteryl esters
(D) Free fatty acids

2014

288. An aldotetrose contains how many chiral carbon atoms in its linear form?
(A) Two
(B) One
(C) Three
(D) Four

2025

289. Mutarotation is an optical phenomenon observed specifically when:
(A) Reducing sugar anomer reaches equilibrium with other anomer
(B) Sucrose is dissolved in water at room temperature
(C) D-isomer physically flips into its L-isomer form
(D) Sugar becomes fully oxidized by a strong mineral acid

2021

290. Identify the incorrect combination concerning oligo- and polysaccharides.
I. Maltose is a reducing disaccharide.
II. Trehalose acts as a stress-protectant sugar in insects and fungi.
III. Glycogen is synthesized solely in plants.
IV. Cellulose microfibrils provide structural rigidity to plant cell walls.
Which of the above statements is incorrect?
(A) III only
(B) I and II
(C) II and IV
(D) IV only

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2022

291. Which storage polysaccharide is composed of two distinct polymeric forms, one strictly linear and the other branched?
(A) Starch
(B) Glycogen
(C) Inulin
(D) Cellulose

2012

292. Chitin differs from cellulose precisely by:
(A) C-2 hydroxyl of glucose replaced by N-acetylamino group
(B) Being a polymer of alpha-1,4 linked glucose monomers
(C) Containing extensive alpha-1,6 branch points throughout
(D) Being categorized as a completely water soluble polymer

2012

293. Heparin acts as a powerful anticoagulant in the bloodstream by:
(A) Activating antithrombin III to inhibit thrombin
(B) Directly destroying red blood cells in the vessels
(C) Chelating all available calcium ions in bloodstream
(D) Directly degrading fibrin polymers into smaller units

2018

294. Individuals with blood type A express a specific glycosyltransferase that attaches which terminal sugar to the H antigen?
(A) N-Acetylgalactosamine
(B) D-Galactose
(C) L-Fucose
(D) N-Acetylglucosamine

2005

295. Match the property/feature with the corresponding class of fatty acids or lipids.
List I: (Lipid/Feature)
P. Essential fatty acids
Q. Trans fatty acids
R. Sphingomyelin
S. Primary bile acids
List II: (Characteristic)
1. Synthesized from cholesterol in the liver
2. Formed as a byproduct of partial hydrogenation
3. Contains a phosphocholine headgroup and ceramide
4. Cannot be synthesized de novo by mammals
(A) P-4, Q-2, R-3, S-1
(B) P-4, Q-3, R-2, S-1
(C) P-2, Q-4, R-1, S-3
(D) P-1, Q-2, R-3, S-4

2006

296. The geometric configuration of nearly all naturally occurring polyunsaturated fatty acids is:
(A) Cis, with double bonds separated by a methylene group
(B) Completely trans in their molecular arrangement
(C) Alternating cis and trans double bond sequences
(D) Conjugated systems of adjacent double bonds in chains

2022

297. Oxidative rancidity is most problematic for lipids that:
(A) Have high proportions of polyunsaturated fatty acids
(B) Have high proportions of short-chain saturated fatty acids
(C) Are composed of highly pure sterols
(D) Are stored in dark, cold, anaerobic environments

2003

298. Triacylglycerols represent the ideal long-term energy storage form because:
(A) Yield twice energy of carbohydrates and are anhydrous
(B) Readily hydrated and expand to fill large vacuoles
(C) Diffuse freely through membranes without transport proteins
(D) Carry high levels of structural nitrogen groups

2015

299. In glycerophospholipids, the fatty acid esterified at the sn-2 position is predominantly:
(A) Unsaturated fatty acid like oleic or arachidonic
(B) Short-chain saturated fatty acid chain structure
(C) Straight-chain saturated fatty acid like palmitic
(D) Fatty acid that is exclusively in the trans form

2010

300. The basic functional role of the sphingosine backbone in ceramide is structurally analogous to which component in triacylglycerols?
(A) Functional role of the phosphate group in the lipid
(B) Functional role of the choline head group in the lipid
(C) Glycerol backbone and one fatty acid tail
(D) Functional role of the ester linkage in the lipid

****

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ANSWERS

1. (A) Polyhydroxy structure with a terminal aldehyde group
Aldoses are a category of monosaccharides defined by the presence of a terminal aldehyde functional group and multiple hydroxyl groups. This distinguishing feature differentiates them from ketoses, which contain a ketone group. The aldehyde carbon is designated as the first carbon in the chain, influencing the chemical reactivity and structural properties of these sugars in aqueous environments.

2. (C) Diastereomers differing at exactly one specific chiral center
Epimers are specific diastereomers that differ in their three-dimensional configuration at only one chiral carbon atom. While they share the same molecular formula, the spatial arrangement around that single asymmetric center results in distinct physical and biological properties. This relationship is commonly observed between sugars like D-glucose and its C-2 epimer, D-mannose, or C-4 epimer, D-galactose.

3. (A) Trehalose
Trehalose is a unique disaccharide where both anomeric carbons of the two glucose units are involved in an alpha,alpha-1,1-glycosidic bond. Since neither unit has a free hemiacetal group available for oxidation, the sugar is non-reducing and does not undergo mutarotation in solution. This chemical stability makes it an effective biological protectant under various extreme environmental stress conditions.

4. (D) Amylose is linear alpha-1,4; amylopectin is branched via alpha-1,6
Starch consists of two distinct glucose polymers that differ in their connectivity. Amylose is a predominantly linear polymer where glucose units are linked by alpha-1,4-glycosidic bonds, forming a helical structure. In contrast, amylopectin is a highly branched molecule that contains alpha-1,4-linked chains with alpha-1,6-glycosidic linkages occurring at branch points, enhancing its solubility and enzymatic accessibility in tissues.

5. (A) Both A and R are true and R is the correct explanation of A.
Cellulose is composed of linear, unbranched chains of D-glucose connected by beta-1,4-glycosidic linkages. This specific geometry allows the chains to align and form extensive networks of intermolecular hydrogen bonds. These interactions produce strong, insoluble microfibrils that provide plants with high tensile strength and protect the polymer from enzymatic degradation by common organisms that lack the cellulase enzyme.

6. (C) N-acetylglucosamine and glucuronic acid
Hyaluronic acid is a high-molecular-weight glycosaminoglycan found in the extracellular matrix and synovial fluid. Its structure consists of a repeating disaccharide unit composed of D-glucuronic acid and N-acetyl-D-glucosamine. Unlike most other glycosaminoglycans, it is not sulfated and is not covalently linked to a protein core, contributing significantly to the viscosity and lubrication of biological tissues and joints.

7. (D) N-acetylgalactosamine
The ABO blood group system is determined by specific carbohydrate antigens on the surface of red blood cells. The A antigen is formed when a specific glycosyltransferase adds an N-acetylgalactosamine residue to the terminal galactose of the H-substance. This terminal sugar serves as the immunodominant epitope, distinguishing individuals with type A blood from those with type B or O.

8. (A) N-acetylglucosamine and N-acetylmuramic acid
Peptidoglycan, the primary structural component of bacterial cell walls, consists of long polysaccharide chains cross-linked by short peptides. The carbohydrate backbone is composed of alternating units of N-acetylglucosamine and N-acetylmuramic acid connected by beta-1,4-glycosidic bonds. This robust framework provides the cell with mechanical strength and protects it from osmotic lysis, making it a target for various antimicrobial agents.

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9. (B) By counting from the terminal methyl carbon as carbon 1
In the omega nomenclature system for unsaturated fatty acids, the position of the first double bond is identified by counting from the terminal methyl group. The methyl carbon is designated as carbon 1, or the omega carbon. This system is biologically relevant because humans lack enzymes to introduce double bonds beyond carbon 9 relative to the carboxyl end.

10. (A) I, II and III
Fatty acid properties depend heavily on their structure. Trans double bonds allow for a more linear conformation, increasing the melting point compared to bent cis isomers. Longer hydrocarbon chains increase van der Waals interactions, raising the melting point relative to shorter chains. Hydrogenation reduces the number of double bonds, thereby decreasing the susceptibility of fats to oxidative rancidity reactions.

11. (A) Functioning as the main form of concentrated energy storage
Triacylglycerols are the primary molecules for long-term energy storage in mammalian adipose tissue. Because they are highly reduced and anhydrous, they provide more than twice the energy per gram compared to carbohydrates or proteins. This compact storage mechanism allows animals to carry significant metabolic reserves without the weight penalty associated with the hydration required for glycogen or protein storage.

12. (C) Restricted to the inner cytosolic leaflet of the membrane
In healthy, resting mammalian cells, phospholipids are distributed asymmetrically between the two leaflets of the plasma membrane. Phosphatidylserine is actively sequestered in the inner cytosolic leaflet by the action of flippases. The appearance of phosphatidylserine on the outer leaflet serves as a critical biological signal, marking the cell for recognition and engulfment by phagocytes during the process of apoptosis.

13. (D) Sphingosine
Sphingomyelin is a major component of the myelin sheath in nerve cells and belongs to the class of sphingolipids. Its structural foundation is sphingosine, an 18-carbon amino alcohol, rather than glycerol. A fatty acid is attached to the amino group via an amide bond, and a phosphocholine or phosphoethanolamine head group is esterified to the terminal hydroxyl group.

14. (C) Gangliosides contain one or more sialic acid residues
Both cerebrosides and gangliosides are glycosphingolipids, but they differ in the complexity of their carbohydrate moieties. Cerebrosides contain a single monosaccharide, usually glucose or galactose, linked to a ceramide. Gangliosides are more complex, possessing an oligosaccharide chain that always includes at least one sialic acid residue, which imparts a negative charge to the molecule at physiological pH.

15. (B) P-3, Q-1, R-2, S-4
Different extraction methods target specific components based on solubility and tissue properties. Soxhlet extraction uses continuous solvent circulation for neutral lipids in dry samples. The Bligh-Dyer method is optimized for total lipid recovery from high-moisture tissues. Hot aqueous ethanol efficiently extracts low-molecular-weight sugars, while dilute acid is commonly employed to isolate pectin from plant cell wall structural matrices.

16. (D) Five-carbon isoprene units
Sterols, including cholesterol, are synthesized through the isoprenoid pathway. According to the isoprene rule, these molecules are constructed from repeating five-carbon building blocks called isoprene units, specifically isopentenyl pyrophosphate. Through a series of condensation reactions, these units form larger intermediates like squalene, which eventually cyclizes to form the characteristic four-ring steroid nucleus found in all biological sterol molecules.

17. (A) Intestinal bacteria dehydroxylate primary bile acids
Primary bile acids, such as cholic and chenodeoxycholic acid, are synthesized from cholesterol in the liver. Upon secretion into the intestine, they undergo chemical modification by the resident bacterial flora. Specifically, bacteria perform 7-alpha-dehydroxylation, converting cholic acid into deoxycholic acid and chenodeoxycholic acid into lithocholic acid. These modified molecules are categorized as secondary bile acids within the enterohepatic circulation.

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18. (C) Eicosanoids
Arachidonic acid is a 20-carbon polyunsaturated fatty acid that serves as the immediate precursor for the biosynthesis of eicosanoids. These potent signaling molecules include prostaglandins, thromboxanes, and leukotrienes. They are synthesized in response to various stimuli through the cyclooxygenase or lipoxygenase pathways and play critical roles in mediating inflammation, blood clotting, smooth muscle contraction, and other vital physiological processes.

19. (A) Hemicelluloses and tightly bound pectins remain insoluble
Hot water extraction is a common initial step for isolating soluble polysaccharides from plant tissues. However, it is limited because it cannot solubilize structural components that are tightly bound within the cell wall matrix. Hemicelluloses and high-molecular-weight pectins often require harsher conditions, such as alkaline solutions or chelating agents, to break hydrogen bonds and covalent cross-links that maintain wall integrity.

20. (B) I only
The Molisch test is a general qualitative assay used to detect all carbohydrates, as it relies on the dehydration of sugars by concentrated acid to form furfurals. It is not specific to ketoses. In contrast, Benedict's test detects reducing sugars, Seliwanoff's test distinguishes ketoses from aldoses by reaction speed, and Barfoed's test differentiates monosaccharides from disaccharides based on reaction time.

21. (B) Concentrated sulfuric acid and phenol
The phenol-sulfuric acid method is a widely used spectrophotometric technique for the quantitative estimation of total carbohydrates. The procedure involves the addition of concentrated sulfuric acid, which hydrolyzes and dehydrates sugars into furfural derivatives. These derivatives then react with phenol to form a stable, orange-yellow color. The intensity of this color is measured and is proportional to the total carbohydrate concentration.

22. (C) Chloroform and methanol (2:1, v/v)
The Folch method is a standard laboratory procedure for the extraction of total lipids from animal tissues. It utilizes a solvent mixture of chloroform and methanol in a 2:1 ratio by volume. This combination effectively disrupts lipid-protein complexes and solubilizes both polar and non-polar lipid classes. The addition of water or a salt solution results in a biphasic partition.

23. (D) The average molecular weight or chain length of the fatty acids
The saponification number represents the milligrams of potassium hydroxide required to saponify one gram of fat. This value is inversely proportional to the average molecular weight of the fatty acids in the sample. A higher saponification number indicates the presence of shorter-chain fatty acids, as a smaller mass of fat contains more moles of ester bonds requiring neutralization by the alkali.

24. (A) Derivatization into fatty acid methyl esters (FAME)
Gas chromatography requires analytes to be volatile and thermally stable. Since long-chain fatty acids have high boiling points and may degrade, they must be converted into more volatile derivatives, typically fatty acid methyl esters. This transesterification process involves reacting the lipids with methanol and a catalyst, allowing for precise separation and quantification of individual fatty acids in a complex sample.

25. (A) Both A and R are true and R is the correct explanation of A.
Aldohexoses like glucose can form five-membered furanose or six-membered pyranose rings. The pyranose form is significantly more stable because its chair conformation minimizes steric hindrance and angle strain. In contrast, the furanose ring exhibits higher internal strain and eclipsing interactions. Therefore, in aqueous solution, the pyranose form predominates as the thermodynamically favored structure, with furanose present only in trace amounts.

26. (B) Interconversion between anomers via open-chain forms
Mutarotation is the spontaneous change in the optical rotation of a sugar solution until an equilibrium is reached. In D-glucose, this occurs because the alpha and beta anomers interconvert through the transient open-chain form. Each anomer has a different specific rotation, and the final measured rotation reflects the stable mixture of these cyclic forms characteristic of the sugar at a given temperature.

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27. (A) Both anomeric carbons are locked in the glycosidic bond
Mutarotation requires the presence of a free anomeric carbon that can revert to an open-chain form to switch between alpha and beta configurations. In sucrose, the glycosidic bond connects the anomeric carbon of glucose to the anomeric carbon of fructose. Because both reactive centers are occupied in the linkage, the rings cannot open, making sucrose a non-reducing sugar that lacks mutarotation.

28. (C) Glycogen is branched every 8-12 residues, making it highly branched
Both glycogen and amylopectin are branched polymers of alpha-D-glucose with alpha-1,4 linkages in the chains and alpha-1,6 linkages at branch points. The primary difference lies in the frequency of branching. Glycogen, the animal storage form, is more highly branched, with points occurring every 8 to 12 residues. This increased branching provides more non-reducing ends for rapid enzymatic mobilization during energy needs.

29. (D) N-acetyl-D-glucosamine
Chitin is a major structural polysaccharide found in the exoskeletons of arthropods and the cell walls of fungi. It is a linear homopolymer composed of N-acetyl-D-glucosamine units connected by beta-1,4-glycosidic bonds. This structure is chemically similar to cellulose, except that the hydroxyl group at the C-2 position of glucose is replaced by an acetamido group, which enhances interchain hydrogen bonding.

30. (B) I, III and V
Mucopolysaccharides, or glycosaminoglycans, are characterized as long, unbranched chains consisting of repeating disaccharide units. They generally possess a high negative charge density due to the presence of sulfate and carboxyl groups. Chondroitin sulfate is a prominent example found in cartilage. While heparin is an anticoagulant, it is not primarily an intracellular coagulant, and several other glycosaminoglycans are also sulfated.

31. (B) L-fucose
The H antigen serves as the essential precursor for both A and B blood group antigens. It consists of a carbohydrate chain that terminates with an L-fucose residue linked to D-galactose. Individuals with the O blood type lack the specific glycosyltransferases required to add further sugars, leaving the H antigen (with its terminal fucose) as the final structure on their cell surfaces.

32. (D) Glycerol or ribitol phosphate cross-linked to peptidoglycan
Teichoic acids are significant surface components of Gram-positive bacterial cell walls. They are water-soluble polymers composed of repeating units of either glycerol phosphate or ribitol phosphate, often substituted with sugars or amino acids. These polymers are covalently cross-linked to the peptidoglycan layer or anchored to the plasma membrane, where they contribute to the cell's negative surface charge and cation regulation.

33. (A) An 18-carbon chain with double bonds at the 9th and 12th carbons from the carboxyl end
The delta nomenclature system for fatty acids describes the total number of carbons, the number of double bonds, and their specific locations relative to the carboxyl carbon. A designation of 18:2(delta 9,12) indicates an 18-carbon chain with two double bonds. These double bonds are located between carbons 9-10 and 12-13, counting from the carboxyl group as carbon number one.

34. (C) Linoleic acid
Essential fatty acids are those that the human body cannot synthesize de novo because it lacks the necessary desaturase enzymes to introduce double bonds beyond carbon 9. Linoleic acid is a primary example of an essential omega-6 fatty acid. It must be obtained through the diet and serves as a precursor for the synthesis of arachidonic acid and various biologically active eicosanoids.

35. (A) P-2, Q-1, R-4, S-3
Lipid analysis involves several quantitative values to assess quality and composition. The iodine value measures unsaturation, while the acid value quantifies free fatty acids indicating hydrolysis. The peroxide value detects primary oxidation products like hydroperoxides, reflecting early-stage rancidity. The saponification number provides information about the average molecular weight of fatty acids, as it measures the amount of alkali required to neutralize them.

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36. (D) Hydrolytic rancidity
The presence of high levels of free fatty acids in a lipid sample indicates that the triacylglycerols have undergone cleavage of their ester bonds. This process, known as hydrolytic rancidity, is typically catalyzed by lipases or exposure to moisture and heat. It is distinct from oxidative rancidity, which involves the reaction of oxygen with unsaturated double bonds to form peroxides and aldehydes.

37. (B) sn-2
In mammalian triacylglycerols and phospholipids, the distribution of fatty acids on the glycerol backbone is not random. The sn-1 position is typically occupied by a saturated fatty acid, such as palmitic or stearic acid. In contrast, the sn-2 position is predominantly esterified with an unsaturated fatty acid, like oleic or arachidonic acid, which significantly influences the physical properties and metabolic fate.

38. (C) Generating second messengers like IP3 and DAG upon cleavage
Phosphatidylinositol is a minor but vital phospholipid in biological membranes. It serves as a precursor for polyphosphoinositides like PIP2. Upon activation by extracellular signals, the enzyme phospholipase C cleaves PIP2 into two potent second messengers: inositol trisphosphate (IP3) and diacylglycerol (DAG). These messengers initiate downstream signaling cascades, including the mobilization of intracellular calcium and the activation of protein kinase C.

39. (D) Farber disease
Farber disease is a rare lysosomal storage disorder caused by a genetic deficiency of the enzyme acid ceramidase. This enzyme is responsible for breaking down ceramide into sphingosine and free fatty acids. In its absence, ceramide accumulates pathologically within lysosomes across various tissues, leading to symptoms such as painful joint swelling, subcutaneous nodules, and progressive hoarseness due to laryngeal involvement.

40. (A) Reduction of cupric to cuprous ions → Reaction with arsenomolybdate → Color development → Spectrophotometric reading
The Nelson-Somogyi method is a classic colorimetric technique for estimating reducing sugars. The process begins with the reduction of alkaline cupric ions to cuprous oxide by the sugar. This precipitate then reacts with an arsenomolybdate reagent, resulting in the formation of a stable, deep blue molybdenum complex. The intensity of this color is then measured spectrophotometrically to determine the sugar concentration.

41. (B) Chloroplasts
Sulfolipids, specifically sulfoquinovosyldiacylglycerols, are unique glycolipids that contain a sulfonic acid group on a sugar moiety. They are predominantly localized in the thylakoid membranes of chloroplasts in plants and algae. These lipids play an essential role in maintaining the structural integrity and functional efficiency of the photosynthetic apparatus, especially under conditions where phosphate availability is limited in the environment.

42. (B) Can act as zwitterionic surfactants in biological interfaces
Aminolipids are a diverse group of lipids that contain amino acid residues or amino groups within their structure. Because they possess both hydrophobic fatty acid tails and polar, often charged, amino head groups, they act as zwitterionic surfactants. This amphipathic nature allows them to stabilize biological interfaces and influence membrane properties, especially in certain bacteria that utilize them as alternatives to phospholipids.

43. (A) Three cyclohexane rings and one cyclopentane ring
The structural core of all sterols and steroid hormones is the cyclopentanoperhydrophenanthrene nucleus. This polycyclic hydrocarbon consists of seventeen carbon atoms arranged into four fused rings. Specifically, it contains three six-membered cyclohexane rings (labeled A, B, and C) and one five-membered cyclopentane ring (labeled D). Modifications to this nucleus, such as side chains and functional groups, define different steroid molecules.

44. (C) Possessing both hydrophilic and hydrophobic regions
An amphipathic molecule is defined by the presence of distinct regions with different affinities for water. For instance, conjugated bile acids possess a hydrophobic steroid nucleus and

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a hydrophilic side chain containing a carboxyl or sulfonate group. This dual nature allows them to act as detergents, orienting themselves at oil-water interfaces to emulsify dietary fats into small micelles during digestion.

45. (A) Both A and R are true and R is the correct explanation of A.
Thromboxane A_2 is a potent eicosanoid that plays a vital role in hemostasis by promoting platelet aggregation and causing vasoconstriction. It is synthesized within platelets from arachidonic acid through the cyclooxygenase pathway, specifically by the action of thromboxane synthase. Because it is highly unstable, it acts locally to facilitate rapid clot formation at the site of vascular injury.

46. (C) Dissolve tightly bound structural proteins
During the industrial or laboratory extraction of starch from plant sources, such as maize or tubers, a weak alkaline solution is often employed. This treatment helps to solubilize and remove structural proteins, such as zein, that are tightly associated with the starch granules in the endosperm. Eliminating these proteins ensures higher purity and better functional properties of the recovered starch.

47. (B) Furfural or hydroxymethylfurfural derivatives
The Anthrone method is a general colorimetric assay for the determination of total carbohydrates. The process begins with the addition of concentrated sulfuric acid, which hydrolyzes polysaccharides and dehydrates the resulting monosaccharides into furfural or hydroxymethylfurfural. These cyclic derivatives then react with the anthrone reagent to form a blue-green complex, the intensity of which is measured spectrophotometrically at 620 nm.

48. (D) Fehling's reagents are unstable and must be mixed before use
Benedict's and Fehling's tests both detect reducing sugars through copper reduction, but Benedict's is generally preferred for its sensitivity and stability. Fehling's solution consists of two separate components, Fehling A and B, which are unstable when mixed and must be prepared immediately before testing. Benedict's reagent uses sodium citrate as a stabilizer, allowing it to be stored as a single, stable solution.

49. (A) Relative hydrophobicity and lack of polar functional groups
In thin-layer chromatography using a non-polar solvent system, lipid molecules are separated based on their affinity for the mobile phase versus the polar silica gel stationary phase. Neutral lipids, such as cholesteryl esters and triacylglycerols, lack polar head groups and interact weakly with the silica. Consequently, they migrate much faster and have higher R_f values than polar lipids like phospholipids.

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50. (B) III only
Monosaccharides commonly exist as cyclic structures. Pyranose rings are six-membered, while furanose rings are five-membered. While fructose often exists as a furanose in disaccharides like sucrose and polysaccharides like inulin, it is entirely capable of forming a pyranose ring. In fact, in aqueous solution at room temperature, the beta-D-pyranose form is the most abundant configuration of free D-fructose.

51. (A) Non-superimposable mirror images
Enantiomers are a specific type of stereoisomer where two molecules are non-superimposable mirror images of each other. They possess identical physical properties, such as melting points and solubility, but differ in the direction they rotate plane-polarized light. In the D and L nomenclature system for sugars, enantiomers differ in the configuration at every chiral center within the molecular structure.

52. (D) alpha-D-glucopyranosyl-(1→1)-alpha-D-glucopyranoside
Trehalose is a disaccharide composed of two D-glucose units. Its structure is defined by an alpha,alpha-1,1-glycosidic linkage, which connects the anomeric carbons of both glucose molecules. Because both reducing ends are involved in the bond, the molecule is non-reducing. This configuration provides high chemical stability, allowing trehalose to protect cellular structures from damage caused by desiccation or freezing.

53. (B) D-galacturonic acid
Pectin is a complex structural heteropolysaccharide found in the primary cell walls of terrestrial plants. Its main component is polygalacturonic acid, a polymer of D-galacturonic acid units. The gelling properties of pectin, which are essential in the food industry, depend heavily on the degree

of methylation of the carboxyl groups on these uronic acid residues, affecting its interaction with water.

54. (C) Hydrogen bonding between parallel linear beta-1,4 linked chains
Cellulose is a linear homopolymer of D-glucose units linked by beta-1,4-glycosidic bonds. This specific linkage allows the chains to adopt an extended, flat ribbon-like conformation. These chains align in parallel to form microfibrils, which are stabilized by extensive networks of interchain and intrachain hydrogen bonds. This resulting structure provides the high tensile strength and rigidity characteristic of plant cell walls.

55. (A) P-4, Q-3, R-2, S-1
Biological carbohydrates serve specific roles across different domains. Glycogen is the primary storage form in animal liver and muscle. Inulin acts as a storage carbohydrate in specific plant roots like chicory. Peptidoglycan provides structural integrity to bacterial cell walls. Chitin is a vital structural component in the fungal cell walls and the hard exoskeletons of arthropods like insects.

56. (A) Glucuronic acid and N-acetylgalactosamine-sulfate
Chondroitinsulfateisasulfatedglycosaminoglycan that serves as a major structural component of cartilage and connective tissues. It consists of unbranched chains of repeating disaccharide units. Each unit is composed of D-glucuronic acid and N-acetyl-D-galactosamine, with the latter typically sulfated at the C-4 or C-6 position. These highly charged molecules contribute to the tissue's resistance to compression.

57. (B) D-galactose
The antigenic differences between ABO blood groups are determined by terminal sugar residues. The A antigen is characterized by a terminal N-acetylgalactosamine, while the B antigen is formed by the addition of a terminal D-galactose residue to the same H-antigen precursor. These specific additions are catalyzed by A and B glycosyltransferases, which are encoded by different alleles of the ABO gene.

58. (B) Endotoxin
Lipopolysaccharides are major components of the outer membrane of Gram-negative bacteria. The structure consists of an O-antigen, a core oligosaccharide, and a lipid component known as Lipid A. Lipid A is the innermost portion anchored in the membrane and acts as a potent endotoxin. It triggers strong immune responses and is responsible for the systemic toxicity observed during Gram-negative bacterial infections.

59. (A) The presence and number of cis double bonds
The physical state of a fatty acid at room temperature is primarily determined by its melting point, which is influenced by chain length and unsaturation. Cis double bonds introduce a permanent kink in the hydrocarbon chain, preventing tight packing and weakening van der Waals interactions. Consequently, highly unsaturated fats remain liquid (oils), while saturated fats pack efficiently and remain solid.

60. (B) I, III and IV
Acylglycerols serve diverse biological roles. Monoacylglycerols, with their polar hydroxyls and non-polar tails, are effective emulsifiers. The formation of these esters is a dehydration synthesis reaction. While triacylglycerols are storage fats, diacylglycerols act as vital secondary messengers in signaling pathways. However, triacylglycerols do not form bilayers; that role belongs to amphipathic phospholipids which possess a polar head group.

61. (D) Membrane curvature and fusion events
Phosphatidylethanolamine is a major membrane phospholipid with a relatively small head group compared to its fatty acid tails, giving it a conical shape. This geometry exerts lateral pressure within the bilayer, promoting membrane curvature. These structural properties are essential for biological processes involving membrane remodeling, such as vesicle budding, fission, and the fusion of two distinct lipid bilayers.

62. (C) Sphingosine, an 18-carbon amino alcohol
Sphingolipids represent a class of lipids defined by their structural backbone, which is sphingosine. Sphingosine is a long-chain, 18-carbon amino alcohol containing a trans double bond. When a fatty acid is attached to the amino group of sphingosine via an amide bond, the resulting molecule is ceramide. Ceramide serves as the fundamental structural unit for all complex sphingolipids, including sphingomyelins and glycosphingolipids.

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63. (B) beta-glycosidic bond
Cerebrosides are the simplest glycosphingolipids and consist of a ceramide unit linked to a single sugar residue, typically D-glucose or D-galactose. The sugar is connected to the primary hydroxyl group of the sphingosine backbone through a beta-glycosidic bond. Because they lack a phosphate group, cerebrosides are classified as neutral glycolipids and are particularly abundant in the myelin sheaths of nerves.

64. (D) Possess an extra alkyl group on the side chain at C-24
Phytosterols like sitosterol and stigmasterol are plant-derived analogs of cholesterol. They share the same four-ring steroid nucleus and a hydroxyl group at the C-3 position. The primary structural difference lies in the aliphatic side chain attached to C-17. Phytosterols possess an additional alkyl group, such as a methyl or ethyl group, at the C-24 position, which cholesterol lacks.

65. (A) Both A and R are true and R is the correct explanation of A.
Ergosterol is the principal sterol found in the cell membranes of fungi, performing a regulatory role similar to cholesterol in animal cells. Because mammalian cells do not synthesize or utilize ergosterol, it serves as an ideal target for antifungal medications. Drugs like amphotericin B bind directly to ergosterol, while azoles inhibit its biosynthesis, leading to membrane disruption and fungal death.

66. (C) Intestinal lumen via bacterial flora action
Secondary bile acids are not synthesized by the liver but are formed within the intestinal lumen. Primary bile acids secreted into the bile reach the colon, where anaerobic bacteria perform enzymatic modifications. The most significant reaction is 7-alpha-dehydroxylation, which converts cholic acid into deoxycholic acid and chenodeoxycholic acid into lithocholic acid, both of which are then partially reabsorbed.

67. (A) Allergic and inflammatory responses like bronchoconstriction
Leukotrienes are eicosanoid signaling molecules synthesized from arachidonic acid via the lipoxygenase pathway. They are primarily produced by leukocytes and serve as powerful mediators of inflammation and allergic reactions. Leukotrienes induce potent physiological effects, such as the contraction of smooth muscle in the airways (bronchoconstriction), increased vascular permeability, and the recruitment of inflammatory cells to sites of tissue injury.

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68. (B) It dissolves starch without causing significant degradation
Starch is often difficult to solubilize completely in water without forming gels or experiencing retrogradation. Dimethyl sulfoxide (DMSO) is an effective solvent used in starch analysis because it can disrupt the extensive hydrogen bonding between amylose and amylopectin chains. This allows the starch to dissolve completely into a molecularly dispersed state without causing significant hydrolytic degradation of the glycosidic bonds.

69. (B) Monosaccharides from disaccharides
Barfoed's test is a chemical assay used to distinguish between reducing monosaccharides and reducing disaccharides. The reagent contains cupric acetate in a dilute acetic acid medium. In this weakly acidic environment, monosaccharides are oxidized by the cupric ions much faster than disaccharides. Therefore, a brick-red precipitate of cuprous oxide forms within a few minutes for monosaccharides, while disaccharides take much longer.

70. (A) I, II, III and V
Carbohydrate quantification methods rely on specific chemical reactions. The phenol-sulfuric acid method is general, detecting both reducing and non-reducing sugars via dehydration. The Nelson-Somogyi assay specifically requires free anomeric carbons to reduce copper, so non-reducing sugars do not react. Colorimetric measurements for the anthrone method are typically performed at 620 nm. Sulfuric acid acts as both a solvent and a reactant.

71. (D) Highly unsaturated, heat-labile lipids
Soxhlet extraction involves the continuous circulation of boiling solvent through a sample over several hours. While effective for stable neutral lipids, the prolonged exposure to high temperatures and oxygen can cause the degradation of heat-sensitive compounds. Highly unsaturated lipids, such as certain polyunsaturated fatty acids, are prone to oxidation and polymerization under these conditions, making alternative cold extraction methods preferable.

72. (A) Peroxide value
The peroxide value is a crucial chemical index used to measure the extent of primary oxidation in fats and oils. It quantifies the concentration of hydroperoxides, which are the initial products formed when oxygen reacts with unsaturated fatty acids. Since hydroperoxides are unstable and eventually break down into secondary products like aldehydes, a high peroxide value indicates early-stage oxidative rancidity.

73. (B) Helium or Nitrogen
In gas chromatography, a carrier gas serves as the mobile phase to transport the vaporized sample through the column. The ideal carrier gas must be chemically inert to prevent reaction with the analyte or stationary phase. Helium and nitrogen are the most commonly used gases for fatty acid analysis. Helium is often preferred for its superior efficiency and velocity characteristics in capillary columns.

74. (B) D-glucose and D-mannose
Epimers are stereoisomers that differ in configuration at only one asymmetric center. D-glucose and D-mannose are a classic example of epimers, as they are identical in structure except for the orientation of the hydroxyl group at the C-2 position. Similarly, D-glucose and D-galactose are C-4 epimers. D-fructose is a functional isomer (ketose), not an epimer, of D-glucose.

75. (A) Both A and R are true and R is the correct explanation of A.
Lactose is a disaccharide composed of galactose and glucose. The glycosidic linkage is formed between the anomeric C-1 of galactose and the C-4 of glucose. Consequently, the anomeric carbon at C-1 of the glucose residue remains free and can exist in an open-chain form with a reactive aldehyde group. This allows lactose to reduce oxidizing agents and classify as a reducing sugar.

76. (C) Configuration difference at the new chiral center upon cyclization
Anomerism is a specific type of stereoisomerism found in cyclic sugars. When a linear monosaccharide undergoes cyclization to form a hemiacetal or hemiketal, the carbonyl carbon becomes a new asymmetric center, known as the anomeric carbon. The resulting isomers, designated as alpha and beta, differ only in the spatial orientation of the hydroxyl group at this specific carbon atom relative to the ring.

77. (D) alpha-1,4 glycosidic bonds
Glycogen phosphorylase is the key regulatory enzyme in glycogenolysis, the process of breaking down glycogen to release glucose. It catalyzes the phosphorolytic cleavage of alpha-1,4-glycosidic bonds from the non-reducing ends of the glycogen molecule. This reaction produces glucose-1-phosphate. The enzyme continues until it reaches a point near a branch, as it cannot cleave the alpha-1,6-glycosidic bonds at the branch points.

78. (C) Unbranched chains of beta-1,4 linked N-acetylglucosamine
Chitin is a prominent structural polysaccharide that provides rigidity to fungal cell walls and arthropod exoskeletons. It consists of a long, unbranched chain of N-acetyl-D-glucosamine monomers. These units are connected by beta-1,4-glycosidic linkages, a structure that facilitates extensive hydrogen bonding between adjacent chains. This molecular arrangement results in the formation of tough, insoluble fibers that offer significant mechanical protection to the organism.

79. (B) High density of negative charges acting as an anticoagulant
Heparin is a highly sulfated glycosaminoglycan stored in the secretory granules of mast cells. It possesses the highest negative charge density of any known biological molecule due to its numerous sulfate and carboxyl groups. This intense charge allows it to bind and activate antithrombin III, which then inhibits thrombin and other clotting factors. Consequently, heparin serves as a potent and clinically vital anticoagulant.

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80. (B) Spotting the sample → Solvent development → Drying → Visualization with iodine vapor
Thin-layer chromatography of lipids follows a precise sequence to achieve separation and identification. First, the lipid sample is spotted onto the baseline of a silica gel plate. The plate is then placed in a chamber where the mobile phase solvent develops upward, separating lipids by polarity. After the plate is removed and dried, the spots are visualized, often using iodine vapor for non-destructive detection.

81. (A) The peptidoglycan layer or membrane lipids
Teichoic acids are structural polymers essential to the Gram-positive bacterial cell envelope. They are classified into two types based on their anchoring. Wall teichoic acids are covalently linked to the N-acetylmuramic acid residues of the thick peptidoglycan layer. Lipoteichoic acids, however, possess a lipid tail that anchors them directly into the cytoplasmic membrane, spanning the entire width of the peptidoglycan wall.

82. (C) Vaccenic acid
While most trans fatty acids in the diet are products of industrial hydrogenation, some occur naturally in the milk and fat of ruminant animals like cows and sheep. Vaccenic acid is a prominent naturally occurring trans fatty acid formed by the biohydrogenation of unsaturated fats by rumen bacteria. Unlike industrial trans fats, moderate consumption of vaccenic acid is not generally associated with the same cardiovascular risks.

83. (A) An increase in the degree of unsaturation
The melting point of a fatty acid is determined by the strength of the intermolecular forces between the hydrocarbon chains. Saturated chains pack tightly, resulting in higher melting points. Introducing double bonds, particularly in the cis configuration, creates kinks that disrupt this packing and weaken van der Waals interactions. Therefore, as the number of double bonds increases, the melting point of the fatty acid significantly decreases.

84. (C) IV only
Mono- and diacylglycerols differ from triacylglycerols in their physical and biological properties. Because they possess one or two free, polar hydroxyl groups on the glycerol backbone, they are significantly more polar than the completely non-polar triacylglycerols. This polarity allows them to act as effective emulsifiers. Triacylglycerols are actually the least capable of emulsification and must be hydrolyzed before absorption across the intestinal lining.

85. (A) P-2, Q-1, R-4, S-3
Qualitative carbohydrate tests utilize specific chemical principles for identification. The Molisch test involves dehydration to furfurals which react with alpha-naphthol. Benedict's test relies on the reduction of cupric ions by reducing sugars. Seliwanoff's test uses resorcinol to detect ketoses via rapid color development, while Bial's test utilizes orcinol to specifically identify pentoses through the formation of a characteristic green complex.

86. (C) A phosphocholine or phosphoethanolamine head group
Sphingomyelin is a unique sphingolipid because it contains a phosphate group, making it both a sphingolipid and a phospholipid. It is composed of a ceramide unit, which consists of sphingosine and a fatty acid, linked to a polar head group. This head group is typically phosphocholine or phosphoethanolamine. This structure distinguishes it from neutral glycosphingolipids, which contain sugars instead of phosphate-linked head groups.

87. (D) Gaucher disease
Gaucher disease is the most common lysosomal storage disorder, caused by a deficiency of the enzyme beta-glucocerebrosidase. This enzyme is responsible for the hydrolysis of glucocerebroside into ceramide and glucose. In its absence, the lipid glucocerebroside accumulates pathologically within the lysosomes of macrophages, particularly in the spleen, liver, and bone marrow, leading to systemic complications and characteristic "Gaucher cells."

88. (A) Sulfonic acid derivative of a hexose linked to diacylglycerol
Sulfoquinovosyl diacylglycerol (SQDG) is a unique sulfur-containing glycolipid found in photosynthetic membranes. Its structure features a sulfoquinovose sugar, which is a derivative of glucose where the C-6 hydroxyl is replaced by a sulfonic acid group. This sugar is linked via a glycosidic bond to a diacylglycerol backbone. The negatively charged sulfonate group allows SQDG to functionally mimic phospholipids in the thylakoid membrane.

89. (B) Bacteria cultivated under phosphate-limiting conditions
Aminolipids, such as ornithine lipids, are phosphorus-free lipids found in the membranes of various bacterial species. These lipids contain an amino acid, like ornithine, linked to fatty acids. Their synthesis is often induced or significantly increased when bacteria are grown in environments where phosphate is scarce. By substituting aminolipids for phospholipids,

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bacteria can conserve precious phosphate for essential molecules like DNA, RNA, and ATP.

90. (A) I and II
Sterols are essential components of biological membranes. Cholesterol regulates fluidity in animal cells by preventing extremes in membrane packing. Plant phytosterols are structurally similar to cholesterol and can compete with it for incorporation into micelles in the intestine, thereby reducing cholesterol absorption. Ergosterol is the fungal equivalent, but it differs from cholesterol by having an extra double bond and a methyl group.

91. (A) Lower pKa to ensure ionization and effectiveness in the intestine
Before secretion into the bile, primary bile acids are conjugated with the amino acids glycine or taurine in the liver. This modification significantly lowers the pK_a of the molecule. At the alkaline pH of the small intestine, conjugated bile salts are fully ionized and more water-soluble than the original bile acids. This ensures they remain effective as detergents for emulsifying dietary fats.

92. (C) Cyclooxygenase (COX)
The biosynthesis of prostaglandins begins with the release of arachidonic acid from membrane phospholipids. The rate-limiting step in their synthesis is catalyzed by cyclooxygenase, also known as prostaglandin H synthase. This bifunctional enzyme converts arachidonic acid into the unstable intermediate prostaglandin H2. PGE2 and other specific prostaglandins are then formed by downstream synthases, playing roles in inflammation, fever, and pain.

93. (D) Single-phase system partitioning into two phases upon water addition
The Bligh-Dyer method is an efficient lipid extraction technique that utilizes a mixture of chloroform, methanol, and the water naturally present in the tissue. Initially, these solvents form a single, homogenous phase that penetrates the tissue and solubilizes lipids. Upon the addition of a specific amount of water, the system partitions into two distinct layers, with the lipids concentrated in the lower chloroform phase.

94. (C) Halogen absorption by carbon-carbon double bonds in a lipid
The iodine value is a quantitative measure of the total degree of unsaturation in a fat or oil. It is defined as the number of grams of iodine absorbed by 100 grams of the lipid sample. During the assay, iodine or another halogen reacts with the carbon-carbon double bonds in the fatty acid chains. A higher iodine value directly correlates with a greater number of double bonds.

95. (A) Both A and R are true and R is the correct explanation of A.
Optical activity is the ability of a substance to rotate the plane of polarized light, a property caused by molecular asymmetry. D-glucose is optically active because its open-chain structure contains four chiral (asymmetric) carbon atoms at positions C-2, C-3, C-4, and C-5. Each chiral center contributes to the overall rotation, and the specific arrangement of atoms ensures that the molecule lacks a plane of symmetry.

96. (D) Cholesteryl esters
In thin-layer chromatography, the migration rate of a lipid depends on its polarity relative to the solvent system and the stationary phase. In a standard non-polar solvent mixture like hexane and diethyl ether, the least polar lipids migrate the furthest. Cholesteryl esters are extremely non-polar because the hydroxyl group of cholesterol is esterified with a fatty acid. Consequently, they migrate closest to the solvent front.

97. (A) Methylation analysis followed by GC-MS
Determining the precise linkage pattern in a complex polysaccharide requires breaking it down while preserving information about the original connections. Methylation analysis involves saturating all free hydroxyl groups with methyl groups, followed by hydrolysis and reduction. The resulting partially methylated alditol acetates are analyzed by gas chromatography-mass spectrometry. The positions lacking methyl groups reveal where the glycosidic bonds were originally located in the polymer chain.

98. (C) Ketoses dehydrate more rapidly to form furfurals in acid
Seliwanoff's test is a colorimetric assay used to distinguish between aldoses and ketoses. When heated with concentrated hydrochloric acid, all sugars dehydrate to form furfurals, but ketoses undergo this reaction much more rapidly than

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aldoses. The resulting furfural then reacts with resorcinol to produce a cherry-red color. Under standard test conditions, ketoses yield this color within minutes, whereas aldoses react much more slowly.

99. (A) Chair conformation
The six-membered pyranose ring of D-glucose is not flat but adopts a puckered conformation to minimize steric strain and bond angle distortion. The chair conformation is the most thermodynamically stable form because it allows the bulky substituents, such as the hydroxyl groups and the hydroxymethyl group, to occupy equatorial positions. This arrangement minimizes 1,3-diaxial interactions compared to the less stable boat or twist-boat forms.

100. (A) III only
Disaccharides are characterized by their component monosaccharides and the specific glycosidic linkages between them. Maltose consists of two glucose units with an alpha-1,4 bond. Sucrose contains glucose and fructose linked alpha-1,beta-2. Lactose features a beta-1,4 linkage between galactose and glucose. However, cellobiose is defined by a beta-1,4-glycosidic bond, not an alpha bond, which distinguishes it as a repeating unit of cellulose.

101. (D) Alpha-1,6 branch points preventing tight crystalline packing
Amylopectin is a highly branched polymer of glucose. The presence of alpha-1,6 branch points every 24 to 30 residues prevents the chains from aligning into the tight, crystalline structures seen in linear amylose. This branching creates a more open, expanded molecular structure that allows for better hydration and the formation of stable suspensions in water. Amylose, being linear, tends to retrograde and precipitate more easily.

102. (B) Intramolecular and intermolecular hydrogen bonds
Cellulose fibers possess remarkable mechanical strength and chemical resistance. This stability arises from the arrangement of linear beta-1,4-linked glucose chains into parallel bundles. The structure is reinforced by a complex network of hydrogen bonds. Intramolecular hydrogen bonds stabilize individual chains, while intermolecular hydrogen bonds between adjacent chains lock them together into tough, insoluble microfibrils that form the structural backbone of plant cell walls.

103. (D) Hyaluronic acid
Glycosaminoglycans are long, unbranched polysaccharides composed of repeating disaccharide units. Most members of this family, such as keratan sulfate, dermatan sulfate, and heparan sulfate, contain sulfate groups that contribute to their high negative charge. Hyaluronic acid is the notable exception; it is a non-sulfated glycosaminoglycan. Additionally, it consists of much longer chains and is not covalently attached to a protein to form proteoglycans.

104. (D) Glycolipids and Glycoproteins
The ABO blood group antigens are oligosaccharide structures located on the external surface of the red blood cell membrane. These antigenic determinants are covalently attached to either membrane-spanning proteins (glycoproteins) or to ceramide lipids (glycosphingolipids). The specific sequence of sugars in these oligosaccharides determines the blood type, and their presence on these glycoconjugates allows them to be recognized by the immune system.

105. (A) P-3, Q-1, R-4, S-2
Fatty acids are classified by their carbon chain length and the number and position of double bonds. Palmitic acid is a 16-carbon saturated fatty acid (16:0). Oleic acid is an 18-carbon monounsaturated fatty acid with a double bond at carbon 9 (18:1). Linoleic acid has two double bonds (18:2), while arachidonic acid is a 20-carbon polyunsaturated fatty acid with four double bonds at specific delta positions.

106. (D) N-acetylmuramic acid
The peptidoglycan layer of bacterial cell walls consists of glycan strands cross-linked by short peptides. These peptides are covalently attached to the lactyl group of the N-acetylmuramic acid (MurNAc) residues. The N-acetylglucosamine (GlcNAc) units in the backbone do not have these peptide attachments. This cross-linking between MurNAc units in adjacent strands provides the structural rigidity necessary for the cell wall to resist osmotic pressure.

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107. (D) It serves as a precursor for anti-inflammatory eicosanoids
Alpha-linolenic acid is an essential omega-3 fatty acid that mammals must obtain from their diet. It serves as the primary precursor for the synthesis of longer-chain omega-3 fatty acids, such as eicosapentaenoic acid (EPA). These fatty acids are utilized to produce eicosanoids that typically have anti-inflammatory effects, contrasting with the often pro-inflammatory eicosanoids derived from omega-6 fatty acids like arachidonic acid.

108. (A) Cis double bonds introduce kinks, disrupting chain packing
Saturated fatty acids have flexible, straight hydrocarbon chains that can pack tightly together, maximizing van der Waals interactions and resulting in higher melting points. In contrast, naturally occurring unsaturated fatty acids usually possess cis double bonds. These bonds introduce a rigid "kink" in the chain, preventing close packing and significantly weakening the attractive forces between molecules. Consequently, unsaturated fatty acids have much lower melting points.

109. (A) Formation of trans fatty acids
Partial hydrogenation is a process used in the food industry to convert liquid vegetable oils into semi-solid fats by adding hydrogen to some double bonds. A common, unintended side effect of this process is the isomerization of remaining cis double bonds into the trans configuration. Unlike cis fats, trans fatty acids are linear and behave physically like saturated fats, but their consumption is strongly linked to increased cardiovascular disease risk.

110. (A) I, II and IV
Glycerophospholipids are amphipathic molecules with diverse roles. Phosphatidylcholine is a primary structural lipid in the outer leaflet of plasma membranes. Cardiolipin is uniquely concentrated in the inner mitochondrial membrane, where it supports respiratory protein function. Phosphatidylinositol is a signaling precursor that can be phosphorylated to PIP2. However, phosphatidylserine is negatively charged, not positive, and these lipids are amphipathic rather than strictly hydrophobic.

111. (D) Pancreatic lipase
The digestion of dietary triacylglycerols occurs primarily in the small intestine. The enzyme pancreatic lipase is secreted into the duodenum, where it acts at the oil-water interface of emulsified fat droplets. It specifically catalyzes the hydrolysis of the ester bonds at the sn-1 and sn-3 positions of the triacylglycerol molecule, producing two free fatty acids and one 2-monoacylglycerol, which are then absorbed.

112. (B) The myelin sheath of nerve cells
Sphingomyelin is a critical sphingolipid found in the plasma membranes of most animal cells, but it is particularly abundant in the myelin sheath. This specialized membrane structure wraps around the axons of neurons, providing electrical insulation that significantly increases the speed of nerve impulse conduction. The unique structural properties of sphingomyelin contribute to the stability and low permeability of this insulating layer.

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113. (D) Cellular recognition markers and receptors on the cell surface
Gangliosides are complex glycosphingolipids found predominantly on the outer leaflet of plasma membranes, especially in the central nervous system. Their large, diverse oligosaccharide head groups extend into the extracellular space, where they function as markers for cellular recognition and as specific receptors for various hormones and bacterial toxins. They play vital roles in cell-cell communication, signal transduction, and the regulation of immune responses.

114. (D) Phospholipids
Sulfoquinovosyl diacylglycerol (SQDG) is a sulfur-containing glycolipid found in chloroplast thylakoid membranes. Research indicates that when plants are grown under phosphate-limiting conditions, they significantly increase the synthesis of SQDG and other galactolipids. These phosphorus-free lipids can functionally substitute for phospholipids like phosphatidylglycerol in the membrane, allowing the plant to conserve scarce phosphate for essential metabolic processes and genetic material synthesis.

115. (A) Both A and R are true and R is the correct explanation of A.
Cholesterol is a vital regulator of membrane fluidity in animal cells. Its rigid four-ring steroid nucleus intercalates between fatty acid chains. At high temperatures, the bulky structure restricts the movement of these chains, preventing the membrane from becoming too fluid. Conversely,

at low temperatures, it prevents the fatty acids from packing tightly into a solid crystalline state, thereby maintaining membrane flexibility and function.

116. (B) Cholesterol
Primary bile acids, including cholic acid and chenodeoxycholic acid, are synthesized exclusively in the liver from cholesterol. This complex multi-step pathway involves the hydroxylation of the steroid nucleus, the saturation of double bonds, and the oxidative cleavage of the aliphatic side chain to form a carboxyl group. These bile acids are essential for the emulsification and absorption of dietary lipids and fat-soluble vitamins.

117. (A) Beta-hydroxy ketone group on the cyclopentane ring
Prostaglandins are a family of eicosanoids characterized by a 20-carbon skeleton containing a five-membered cyclopentane ring. The different classes of prostaglandins are distinguished by the substituents on this ring. The PGE series is specifically identified by the presence of a beta-hydroxy ketone group—a hydroxyl group at C-11 and a ketone group at C-9. These molecules are potent mediators of various physiological signals.

118. (D) Precipitate the soluble polysaccharides
In the laboratory isolation of carbohydrates from plant tissues, a hot water extract is often treated with ethanol to achieve a final concentration of about 70-80%. While low-molecular-weight sugars remain soluble in this mixture, larger polysaccharides like starch and various pectins become insoluble and precipitate out of the solution. This allows for the effective separation of complex polymers from simple soluble sugars for further analysis.

119. (B) Furfural or its derivatives
The Molisch test is a general qualitative assay for all carbohydrates. When a sample is treated with concentrated sulfuric acid, any carbohydrates present are dehydrated. Pentoses are converted to furfural, while hexoses are converted to hydroxymethylfurfural. These cyclic aldehydes then react with alpha-naphthol to form a characteristic purple or violet ring at the junction of the two liquids, indicating the presence of saccharides.

120. (A) Addition of methanolic HCl/BF_3 → Heating → Cooling → Extraction with non-polar solvent (e.g., hexane)
The preparation of fatty acid methyl esters (FAMEs) for gas chromatography involves a transesterification reaction. The lipid sample is mixed with a methylating reagent, such as methanolic hydrochloric acid or boron trifluoride, and heated to drive the reaction. After cooling, the resulting FAMEs, which are non-polar, are extracted into a solvent like hexane. This extraction step separates the volatile esters from the polar catalysts and glycerol.

121. (D) Blue-green
The Anthrone method is a colorimetric technique used for the quantitative estimation of total carbohydrates. Sugars react with anthrone reagent in the presence of concentrated sulfuric acid to produce a characteristic blue-green color. The intensity of this color is directly proportional to the amount of sugar present in the sample and is typically measured using a spectrophotometer at a wavelength of approximately 620 nm.

122. (C) Vaporize, condensed, and percolated through the sample
Soxhlet extraction is a continuous automated method for isolating lipids from solid samples. The solvent is heated in a flask to vaporization, and the vapors travel to a condenser where they turn back into liquid. This fresh solvent then drips into a thimble containing the sample, percolating through it to dissolve the lipids. When the extraction chamber fills, the solvent siphons back into the flask, repeating the cycle.

123. (D) Short-chain fatty acids
The saponification number is defined as the milligrams of potassium hydroxide required to saponify one gram of fat. Because each triacylglycerol molecule requires three moles of KOH, a sample containing smaller, lighter fatty acids will have more molecules per gram than a sample with longer, heavier ones. Therefore, a high saponification value indicates a high proportion of short-chain fatty acids in the lipid sample.

124. (A) Boiling point and affinity for the stationary phase
Gas chromatography separates a mixture of fatty acid methyl esters (FAMEs) based on their physical and chemical properties as they pass

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through a column. The separation is driven by the differential partitioning of each ester between the inert carrier gas and the stationary phase coating the column walls. The specific boiling point of each FAME and its degree of interaction with the stationary phase determine its retention time.

125. (A) P-3, Q-4, R-2, S-1
Polysaccharides fulfill diverse structural and storage roles in living organisms. Glycogen serves as the primary energy reserve in mammalian tissues. Hyaluronic acid is a glycosaminoglycan that provides essential lubrication in joints. Teichoic acids are important for cation regulation in Gram-positive bacterial walls. Chitin is a robust structural polymer that forms the basis of the arthropod exoskeleton, providing protection and support for these animals.

126. (A) Converted to aldoses via enediol intermediates in alkali
Benedict's test detects reducing sugars through the reduction of cupric ions in an alkaline medium. Although ketoses like fructose lack a terminal aldehyde group, they test positive because the alkaline conditions of the reagent promote a process called tautomerization. Through a transient enediol intermediate, the ketone group of fructose is converted into an aldehyde group (forming glucose or mannose), which then reacts with the copper reagent.

127. (B) beta-D-fructofuranose
Sucrose is a disaccharide formed by the condensation of one molecule of D-glucose and one molecule of D-fructose. In this structure, the fructose moiety exists in a five-membered ring form known as a furanose. Specifically, it is the beta-anomer of D-fructofuranose that participates in the glycosidic bond, linking its anomeric C-2 to the anomeric C-1 of the alpha-D-glucopyranose unit.

128. (D) Position of the C-1 hydroxyl relative to the ring plane
Alpha and beta anomers are stereoisomers that differ only in the configuration at the anomeric carbon (C-1 for glucose) after the sugar cyclizes into a pyranose ring. In the standard Haworth projection, the alpha-anomer is defined by the C-1 hydroxyl group pointing downwards (trans to the CH2OH group), while the beta-anomer has the C-1 hydroxyl pointing upwards (cis to the CH2OH group).

129. (C) Amylose stains deep blue, amylopectin stains red-violet
Iodine staining is a classic test for starch based on the formation of polyiodide complexes. Amylose has a linear structure that forms a tight helix, which can perfectly accommodate iodine molecules to produce a characteristic deep blue color. In contrast, the branched structure of amylopectin prevents the formation of long helices, resulting in the trapping of fewer iodine atoms and the development of a red-violet or brownish color.

130. (B) III only
Structural polysaccharides like cellulose and pectin are generally resistant to simple biological degradation. Cellulose forms extended ribbons stabilized by hydrogen bonds, and pectin is composed of polygalacturonic acid. Chitin, while a tough structural polymer of N-acetylglucosamine, is not completely resistant to all enzymes; it can be cleaved by lysozyme and specific chitinases, which target the beta-1,4-glycosidic bonds between its monomeric units.

131. (D) Keratan sulfate
Most glycosaminoglycans (GAGs) are composed of repeating disaccharide units that include an amino sugar and a uronic acid, such as glucuronic or iduronic acid. Keratan sulfate is unique among the common GAGs because it does not contain a uronic acid. Instead, its repeating disaccharide unit consists of galactose and N-acetylglucosamine-6-sulfate. It is found primarily in the cornea, cartilage, and bone tissue.

132. (A) Anti-A and Anti-B antibodies
The ABO blood group system is defined by the presence of specific antigens on red blood cells and the corresponding antibodies in the plasma. Individuals with type O blood lack both A and B antigens on their cell surfaces. Because their immune systems have not been sensitized to these antigens, they naturally produce both anti-A and anti-B antibodies, which would react against transfused type A or B blood.

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133. (C) O-specific polysaccharide side chain (O-antigen)
Lipopolysaccharides (LPS) are complex molecules in the outer membrane of Gram-negative bacteria. While Lipid A provides toxicity and the core oligosaccharide is relatively conserved, the O-specific polysaccharide side chain, or O-antigen, is highly variable. The length and sugar composition of this chain differ significantly between bacterial strains and species, and this variation determines the specific serological identity and immunological recognition of the bacteria.

134. (A) 18:0
Stearic acid is one of the most common long-chain saturated fatty acids found in both animal fats and vegetable oils. In the standard lipid nomenclature, it is designated as 18:0. This indicates that the molecule consists of an unbranched 18-carbon chain with zero double bonds. Its saturated nature allows it to be solid at room temperature and contributes to its stability against oxidation.

135. (A) Both A and R are true and R is the correct explanation of A.
The melting point of saturated fatty acids is directly proportional to their carbon chain length. As the number of carbon atoms in the chain increases, the total surface area for molecular contact also increases. This allows for more extensive van der Waals interactions between adjacent hydrocarbon chains. Consequently, more thermal energy is required to overcome these attractive forces and transition the substance from a solid to a liquid phase.

136. (A) Stearic acid
Linoleic acid is an 18-carbon polyunsaturated fatty acid with two double bonds. During the process of complete hydrogenation, hydrogen atoms are added across both double bonds in the presence of a catalyst, converting them into single bonds. Since the original carbon skeleton contains 18 atoms, the saturated product of this reaction is octadecanoic acid, which is commonly known as stearic acid.

137. (C) Highly reduced, anhydrous, and densely packed
Triacylglycerols are the most efficient form of metabolic energy storage. They are highly reduced, meaning they yield a large amount of energy upon oxidation. Furthermore, because they are non-polar and hydrophobic, they are stored in an anhydrous (water-free) state. This allows for extremely dense packing in adipose tissue, providing far more energy per unit of weight and volume than the hydrated storage forms of carbohydrates like glycogen.

138. (C) Phosphatidylserine
Phosphatidylserine is a glycerophospholipid that carries a net negative charge at physiological pH. In a healthy cell, it is localized almost exclusively in the inner leaflet of the plasma membrane. During the early stages of apoptosis, this asymmetry is lost, and phosphatidylserine is exposed on the outer leaflet. This "eat-me" signal is recognized by phagocytic cells, facilitating the orderly removal of the dying cell without triggering inflammation.

139. (D) Amide bond
Ceramides are the structural precursors for all complex sphingolipids. They consist of a sphingosine backbone and a fatty acid. Unlike triacylglycerols, where fatty acids are linked to glycerol via ester bonds, the fatty acid in a ceramide is covalently attached to the amino group at the C-2 position of the sphingosine via an amide bond. This linkage is chemically stable and characteristic of the entire sphingolipid family.

140. (A) Steeping in sulfurous acid → Wet milling → Screening → Centrifugation/washing → Drying
The wet-milling process for isolating starch from grains like corn begins with steeping the kernels in a sulfurous acid solution to soften them and break down protein matrices. The softened grain is then wet-milled to release starch granules. Screening removes the fiber and germ, followed by centrifugation to separate the starch from the protein (gluten). Finally, the purified starch is washed and dried into a powder.

141. (B) Glyceroglycolipids
Sulfolipids, such as sulfoquinovosyl diacylglycerol (SQDG), are essential components of photosynthetic membranes. They are structurally classified as glyceroglycolipids because they consist of a diacylglycerol backbone linked to a sugar moiety (sulfoquinovose). Unlike phospholipids, they do not contain a phosphate group; instead, they possess a sulfonic acid group on the sugar, which provides a negative

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charge and maintains the functional integrity of chloroplast membranes.

142. (B) Amino acid linked to a lipid moiety via ester/amide bonds
Aminolipids are a unique class of lipids found primarily in certain bacteria. They are characterized by the presence of an amino acid residue, such as ornithine, lysine, or glycine, covalently linked to a lipid moiety. This linkage usually involves an amide or ester bond between the amino acid and a fatty acid or a diacylglycerol-like structure. These lipids provide a phosphorus-free alternative for membrane construction in phosphate-poor environments.

143. (A) 7-Dehydrocholesterol
In humans, the synthesis of Vitamin D_3 (cholecalciferol) occurs in the skin upon exposure to ultraviolet B (UVB) radiation. The direct precursor for this process is 7-dehydrocholesterol, an intermediate in the cholesterol biosynthetic pathway. UVB light breaks the B-ring of the steroid nucleus to form pre-vitamin D_3, which then spontaneously isomerizes into Vitamin D_3. This synthesis is critical for maintaining calcium homeostasis and bone health.

144. (C) Hydrophilic alpha face and hydrophobic beta face
Bile acids are amphipathic molecules with a unique spatial arrangement that makes them effective detergents. The four-ring steroid nucleus is relatively flat, with the hydroxyl groups all oriented on one side (the alpha face), making it hydrophilic. The other side (the beta face), consisting of methyl groups and the hydrocarbon skeleton, is hydrophobic. This polarity allows them to form micelles and emulsify dietary fats in the aqueous environment of the intestine.

145. (B) I, II and IV
Prostaglandins are a group of eicosanoids synthesized in nearly all mammalian tissues from arachidonic acid. They are characterized by a 20-carbon structure with a five-membered ring. Prostaglandins act as autocrine or paracrine mediators, meaning they exert their effects locally near the site of synthesis. Because they are chemically unstable and rapidly metabolized, they have an extremely short half-life and do not function as circulating endocrine hormones.

146. (B) Non-polar solvents like hexane or petroleum ether
Neutral lipids, such as triacylglycerols and cholesteryl esters, are highly hydrophobic and lack polar groups. To extract them efficiently without causing chemical degradation, non-polar organic solvents like hexane or petroleum ether are typically used. These solvents easily dissolve the non-polar hydrocarbon chains of the lipids while leaving behind more polar cellular components like proteins, carbohydrates, and polar membrane lipids, facilitating selective isolation and subsequent analysis.

147. (B) Phenol-sulfuric acid method
The phenol-sulfuric acid method is a highly reliable and widely used technique for the quantitative estimation of total carbohydrates in biological samples. The concentrated sulfuric acid used in the reagent hydrolyzes all glycosidic bonds and dehydrates the resulting monosaccharides into furfurals. Because it acts on all types of sugars regardless of their reducing power, it provides a comprehensive measurement of total saccharide content in crude extracts.

148. (D) The degree of hydrolytic rancidity
The acid value is a chemical measurement used to quantify the amount of free fatty acids present in a fat or oil sample. It is defined as the milligrams of potassium hydroxide required to neutralize the free acids in one gram of the lipid. Since free fatty acids are released by the hydrolysis of triacylglycerols, a high acid value indicates significant hydrolytic rancidity, often caused by moisture, heat, or enzyme activity.

149. (A) Biphasic separation with lipids in the lower chloroform layer
The Bligh-Dyer method is designed to extract lipids using a mixture of chloroform, methanol, and water. By carefully adjusting the proportions of these solvents, a single-phase system is initially formed to extract the lipids. The subsequent addition of water or chloroform forces the mixture to separate into two phases. The non-polar lipids and most membrane lipids partition into the lower, denser chloroform layer, while water-soluble contaminants stay in the upper aqueous-methanol phase.

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150. (B) Both A and R are true but R is not the correct explanation of A.
Thin-Layer Chromatography (TLC) is a versatile technique for separating lipid classes based on their relative polarities. The stationary phase (silica gel) is polar, while the mobile phase solvent is typically less polar. Non-polar lipids migrate further because they have less affinity for the silica. While both statements are true, the reason describes the mechanism of separation, rather than explaining the dependency on both phases which is a general principle of chromatography.

151. (B) 4
An aldohexose, such as D-glucose, consists of a six-carbon chain with an aldehyde group at the first carbon. In its linear open-chain form, the carbons at positions 2, 3, 4, and 5 are each bonded to four different groups, making them asymmetric or chiral centers. The number of possible stereoisomers for such a molecule is calculated as 2 to the power of the number of chiral centers.

152. (C) Presence of asymmetric (chiral) carbon atoms
Optical activity is the characteristic ability of a substance to rotate the plane of polarized light. This phenomenon occurs in molecules that lack a plane of symmetry, which in carbohydrates is caused by the presence of one or more asymmetric, or chiral, carbon atoms. These carbons are bonded to four different chemical groups, resulting in non-superimposable mirror-image forms that interact differently with polarized light.

153. (C) Cannot be oxidized by weak oxidizing agents
Trehalose is a disaccharide where two glucose molecules are joined by an alpha,alpha-1,1-glycosidic bond. This linkage involves the anomeric carbons of both glucose units, meaning there are no free hemiacetal groups available to open into a linear form with a reactive aldehyde. Consequently, trehalose is a non-reducing sugar that cannot be oxidized by weak reagents like Benedict's or Fehling's solution.

154. (A) Gelatinization
When starch granules are heated in an excess of water, they undergo a process called gelatinization. The heat disrupts the intermolecular hydrogen bonds between amylose and amylopectin, allowing water to enter and causing the granules to swell significantly. This results in the loss of crystalline structure and the formation of a viscous starch paste. This process is fundamental to the texture of many cooked starch-based foods.

155. (A) P-2, Q-1, R-4, S-3
Lipid analysis utilizes various techniques to determine specific characteristics. Gas chromatography provides a detailed profile of individual fatty acids. Thin-layer chromatography is used to separate lipids into classes like phospholipids and triglycerides. The iodine value titration quantifies the overall degree of unsaturation in the sample. The peroxide value titration measures the concentration of hydroperoxides, which are indicators of the primary stage of oxidative rancidity in fats.

156. (A) Amylose is alpha-1,4 helical; cellulose is beta-1,4 rigid chains
Amylose and cellulose are both linear glucose polymers, but their glycosidic linkages result in drastically different physical properties. Amylose contains alpha-1,4 bonds that cause the chain to coil into a flexible, water-soluble helix. In contrast, cellulose contains beta-1,4 bonds that force the chain into a rigid, extended ribbon-like conformation. These rigid chains form dense microfibrils stabilized by hydrogen bonds, providing the structural strength needed for plant cell walls.

157. (A) Hyaluronidase
Hyaluronidase is a family of enzymes responsible for the degradation of hyaluronic acid, a major component of the extracellular matrix. These enzymes catalyze the hydrolysis of the glycosidic bonds within the polysaccharide chain, reducing its viscosity and increasing tissue permeability. This process is important for normal physiological tissue remodeling, but it is also utilized by certain bacteria and venomous animals to facilitate the spread of toxins.

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158. (A) Alpha-L-fucose linked to a galactose residue
The H antigen is the fundamental carbohydrate precursor for the ABO blood group antigens. Its structure consists of a glycan chain terminating with an alpha-L-fucose residue linked to a D-galactose molecule. Individuals with the O blood type only possess this H antigen. Those with type A or B have additional enzymes that add other specific sugars to this galactose

residue, thereby creating the A or B antigenic determinants.

159. (C) Outer lipid membrane containing LPS
Bacterial cell wall structures differ significantly between Gram-positive and Gram-negative species. Gram-positive bacteria are characterized by a very thick peptidoglycan layer and the presence of teichoic acids. Gram-negative bacteria have a much thinner peptidoglycan layer but are unique in possessing an asymmetrical outer lipid membrane. This outer membrane contains lipopolysaccharides (LPS) and porins, which serve as a protective barrier against various environmental stressors and antibiotics.

160. (B) IV only
Fatty acid nomenclature describes the chain length and unsaturation. Alpha-linolenic acid is 18:3(omega-3), arachidonic acid is 20:4(omega-6), and oleic acid is 18:1(omega-9). The designation 16:0 correctly refers to palmitic acid, which is a saturated 16-carbon fatty acid. Stearic acid, however, is an 18-carbon saturated fatty acid and is correctly designated as 18:0. Therefore, the combination identifying 16:0 as stearic acid is incorrect.

161. (B) Linear chain conformation allowing tight packing
Trans fatty acids contain at least one double bond in the trans configuration. Unlike the bent shape of cis-unsaturated fatty acids, the trans configuration results in a relatively straight, linear hydrocarbon chain. This linear geometry allows trans fatty acids to pack closely together, similar to saturated fatty acids. As a result, they have higher melting points and exhibit physical properties and biological effects comparable to those of saturated fats.

162. (C) Autoxidation of unsaturated fatty acids by free radicals
Oxidative rancidity is a chemical process that leads to the spoilage of fats and oils containing unsaturated fatty acids. It is primarily initiated by autoxidation, where free radicals react with the double bonds in the presence of oxygen. This chain reaction produces hydroperoxides, which eventually decompose into smaller, volatile molecules like aldehydes and ketones. these secondary products are responsible for the unpleasant odors and flavors associated with rancid lipids.

163. (C) Protein Kinase C
Diacylglycerol (DAG) is a vital lipid secondary messenger generated by the hydrolysis of phosphatidylinositol 4,5-bisphosphate (PIP2) by phospholipase C. Once produced, DAG remains within the plasma membrane, where it specifically binds to and activates protein kinase C (PKC). This activation, often requiring calcium ions, allows PKC to phosphorylate various target proteins, thereby regulating numerous cellular processes such as growth, differentiation, and metabolism.

164. (B) Amphipathic nature driving the hydrophobic effect
Glycerophospholipids are amphipathic, possessing a polar, hydrophilic head group and two non-polar, hydrophobic fatty acid tails. When placed in an aqueous environment, these molecules spontaneously organize into a bilayer. This self-assembly is driven by the hydrophobic effect, where the non-polar tails sequester themselves away from water in the interior of the membrane while the polar heads interact with the aqueous surroundings, creating a stable biological barrier.

165. (A) Both A and R are true and R is the correct explanation of A.
Tay-Sachs disease is a severe lysosomal storage disorder caused by a mutation in the HEXA gene, leading to a deficiency of the enzyme hexosaminidase A. This enzyme is required to break down GM2 gangliosides. In its absence, these complex glycosphingolipids accumulate to toxic levels within the lysosomes of neurons. This progressive accumulation causes significant neurological damage, leading to the symptoms characteristic of the disease.

166. (A) Have a sphingosine backbone and lack a phosphate group
Cerebrosides are a class of glycosphingolipids that differ fundamentally from common phospholipids like phosphatidylcholine. Instead of a glycerol backbone, they utilize sphingosine as their structural base. Furthermore, they are neutral lipids because they lack a phosphate group. Instead, a single sugar residue, such as glucose or galactose, is linked to the ceramide. They are essential components of cellular membranes, particularly in the brain and nervous system.

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167. (B) Maintain membrane functionality under phosphate deficiency
Sulfoquinovosyl diacylglycerol (SQDG) is a negatively charged sulfolipid found in the thylakoid membranes of chloroplasts. Its primary physiological role is to provide a phosphorus-free source of anionic lipid. During periods of phosphate starvation, plants upregulate the synthesis of SQDG to replace phospholipids like phosphatidylglycerol. This strategic substitution allows the plant to maintain the structural and functional integrity of its photosynthetic machinery while conserving limited phosphate for other uses.

168. (A) A 17-carbon polycyclic structure
All sterols, including cholesterol and ergosterol, share a fundamental structural core known as the steroid nucleus. This nucleus is a 17-carbon polycyclic structure consisting of four fused rings: three six-membered cyclohexane rings and one five-membered cyclopentane ring. This rigid, planar framework provides the basis for a wide variety of biological molecules, including bile acids and steroid hormones, which are formed by adding specific functional groups and side chains.

169. (A) Have more hydroxyls and a shortened, carboxylated side chain
Bile acids are synthesized from cholesterol in the liver through a series of enzymatic modifications. Compared to cholesterol, bile acids possess additional hydroxyl groups at specific positions (such as C-7 and C-12) and have a shortened aliphatic side chain that terminates in a polar carboxyl group. These structural changes increase the molecule's polarity and amphipathic nature, enabling it to function as an effective detergent in the intestinal lumen.

170. (A) I and III
Eicosanoids are potent signaling molecules with diverse structures. Thromboxanes are characterized by a six-membered ether-containing oxane ring. Leukotrienes are linear molecules that contain three conjugated double bonds and lack a ring structure. While prostaglandins do have a ring, they and other eicosanoids act as local mediators rather than endocrine hormones. Additionally, NSAIDs like aspirin specifically target the cyclooxygenase pathway, not the lipoxygenase pathway responsible for leukotriene synthesis.

171. (A) Disrupts protein-lipid interactions and extracts polar lipids
Brain tissue is uniquely rich in complex polar lipids, such as sphingomyelins and gangliosides, which are often tightly associated with proteins. The Folch method, using a chloroform-methanol mixture, is superior to non-polar solvents like hexane because the methanol helps to disrupt these lipid-protein interactions and effectively solubilizes polar lipids. This ensures a comprehensive and representative extraction of the total lipid profile from the dense, lipid-rich neural tissue.

172. (D) The precipitation of cuprous oxide (Cu2O)
Benedict's test is a semi-quantitative assay for reducing sugars. When a sugar with a free anomeric carbon is heated with the alkaline copper reagent, it reduces the blue cupric (Cu^{2+}) ions to cuprous (Cu^{+}) ions. These cuprous ions then react with hydroxyl ions to form cuprous oxide, which precipitates as a brick-red solid. The final color of the solution depends on the concentration of the sugar present in the sample.

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173. (A) Concentrated sulfuric acid
The phenol-sulfuric acid method is a quantitative spectrophotometric technique for estimating carbohydrates. The key step in this assay is the addition of concentrated sulfuric acid to the aqueous sample. The intense heat and acidic conditions generated by the acid cause the hydrolysis of glycosidic bonds and the subsequent dehydration of the monosaccharides into furfural or hydroxymethylfurfural derivatives. These derivatives then react with phenol to produce a measurable color.

174. (C) Liberation of iodine from KI by lipid hydroperoxides
The peroxide value is a measurement used to determine the degree of primary oxidation in a fat. The chemical principle involves reacting the lipid sample with potassium iodide (KI) in an acidic medium. Any hydroperoxides present in the fat will oxidize the iodide ions, resulting in the liberation of molecular iodine. The amount of iodine released is then quantified by titration with sodium thiosulfate, reflecting the peroxide concentration.

175. (B) Flame Ionization Detector (FID)
In the analysis of fatty acid methyl esters (FAMEs) by gas chromatography, the flame

ionization detector is the most widely used detection system. The FID works by burning the eluting compounds in a hydrogen-air flame, which produces ions. These ions generate an electrical current proportional to the amount of carbon in the sample. This detector is highly sensitive, has a wide linear range, and is robust for lipid analysis.

176. (C) The hydroxyl group at C-1 is drawn below the plane of the ring
The anomeric configuration of cyclic sugars is represented in Haworth projections relative to the ring plane. For D-glucopyranose, the alpha-anomer is distinguished by the position of the hydroxyl group at the C-1 anomeric carbon. In the alpha form, this hydroxyl group is oriented downwards, or below the plane of the ring. This is opposite to the beta-anomer, where the C-1 hydroxyl is oriented upwards, or above the plane.

177. (A) Zero optical rotation
A racemic mixture consists of equal amounts of two enantiomers, which are mirror-image isomers that rotate plane-polarized light in opposite directions. Because each enantiomer rotates the light by the same magnitude but in an opposite direction, their effects perfectly cancel each other out. Consequently, a racemic solution does not demonstrate any net rotation of polarized light and is described as having zero optical activity.

178. (D) beta-1,4 glycosidic bond
Cellobiose is a disaccharide composed of two D-glucose units. It is the fundamental repeating unit of cellulose and is produced during its partial hydrolysis. The two glucose molecules are connected by a beta-1,4-glycosidic bond, which links the anomeric carbon of the first unit to the fourth carbon of the second unit. This specific linkage is responsible for the rigid, linear structure of the parent cellulose polymer.

179. (B) 8 to 12 residues
Glycogen is a highly branched homopolymer of glucose that serves as the primary energy storage molecule in animals. While it contains alpha-1,4-glycosidic bonds in its linear chains, it also features alpha-1,6-glycosidic linkages at its branch points. These branches occur frequently, typically every 8 to 12 glucose residues. This high degree of branching makes glycogen more compact and provides numerous non-reducing ends for rapid enzymatic degradation.

180. (A) Both A and R are true and R is the correct explanation of A.
Pectin is a structural polysaccharide found in fruit cell walls that can form a viscous, gel-like matrix. During juice extraction, this pectin often remains in the liquid, leading to a cloudy appearance and hindering filtration. Pectinase enzymes are added to hydrolyze the glycosidic bonds in the pectin backbone. This breaks down the gel network, allowing the juice to be clarified and improving the efficiency of the extraction process.

181. (A) Chondroitin sulfate
Chondroitin sulfate is the most abundant glycosaminoglycan in the human body. It is a major structural component of the extracellular matrix in connective tissues, particularly cartilage, bone, and heart valves. Its repeating disaccharide units, which are highly sulfated and negatively charged, allow it to bind large amounts of water. This property provides cartilage with its characteristic ability to resist compression and act as a shock absorber in joints.

182. (B) Glycosyltransferases
The biosynthesis of the ABO blood group antigens involves the sequential addition of specific monosaccharides to a common precursor, the H antigen. These reactions are catalyzed by enzymes known as glycosyltransferases. Each blood type is determined by the presence of a specific transferase: the A transferase adds N-acetylgalactosamine, while the B transferase adds galactose. These enzymes are highly specific for both the donor sugar and the acceptor carbohydrate chain.

183. (B) Beta-1,4 glycosidic bond between GlcNAc and MurNAc
Lysozyme is a vital enzyme of the innate immune system that acts as a natural antibacterial agent. Its mechanism of action involves the hydrolysis of the bacterial cell wall peptidoglycan. Specifically, it cleaves the beta-1,4-glycosidic bond between N-acetylglucosamine and N-acetylmuramic acid residues. This degradation weakens the structural integrity of the cell wall, causing the bacteria to burst under internal osmotic pressure, a process known as lysis.

184. (A) Carbon 9
Humans and other mammals possess desaturase enzymes that can introduce double bonds into

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fatty acid chains at the delta-4, delta-5, delta-6, and delta-9 positions. However, they lack the specific enzymes required to insert double bonds beyond carbon 9 relative to the carboxyl group. Because of this limitation, fatty acids with double bonds at the omega-3 or omega-6 positions, like alpha-linolenic and linoleic acid, are essential and must be dietary.

185. (A) P-3, Q-1, R-4, S-2
Lipids are categorized based on their core structural backbones and functional groups. Ceramide is the base unit of sphingolipids, consisting of sphingosine and a fatty acid. Phosphatidylcholine is a standard glycerophospholipid with a glycerol backbone and a phosphate-linked choline. Cholic acid is a primary bile acid derived from the sterol nucleus. Thromboxane is an eicosanoid, a signaling molecule derived from 20-carbon polyunsaturated fatty acids like arachidonic acid.

186. (A) Average molecular weight (chain length) of fatty acids
The saponification value is a chemical index used to estimate the average molecular weight of the fatty acids in a lipid sample. It measures the quantity of alkali needed to completely saponify a fixed mass of fat. Since each triacylglycerol molecule reacts with three moles of alkali, a smaller mass of a fat composed of short-chain fatty acids will contain more molecules and thus have a higher saponification value than a long-chain fat.

187. (A) One glycerol molecule and one fatty acid esterified to it
Monoacylglycerols, also known as monoglycerides, are a class of acylglycerols that consist of a single glycerol molecule. One of the three hydroxyl groups on the glycerol is esterified with a fatty acid, while the remaining two hydroxyl groups remain free. Depending on the position of the ester bond, they are classified as 1-monoacylglycerols or 2-monoacylglycerols. They are important intermediates in lipid metabolism and are widely used as food emulsifiers.

188. (C) Increasing the proportion of cis-unsaturated fatty acids
Biological membrane fluidity is heavily influenced by the fatty acid composition of the phospholipids. Saturated fatty acids are straight and pack tightly, making the membrane more rigid. In contrast, cis-unsaturated fatty acids contain double bonds that create kinks in the hydrocarbon chains. These kinks prevent tight molecular packing and decrease van der Waals interactions, thereby increasing the fluidity and flexibility of the lipid bilayer across various physiological temperatures.

189. (C) Sphingomyelin
Niemann-Pick disease (specifically types A and B) is a lysosomal storage disorder caused by a deficiency in the enzyme acid sphingomyelinase. This enzyme is responsible for the breakdown of sphingomyelin into ceramide and phosphocholine. In its absence, sphingomyelin accumulates to toxic levels within lysosomes in various organs, particularly the liver, spleen, and brain. This lead to severe systemic and neurological symptoms, including organomegaly and progressive cognitive decline.

190. (B) II only
Glycolipids are classified based on the complexity of their carbohydrate head groups. Cerebrosides are simple glycolipids with a single sugar residue linked to ceramide. Globosides are neutral glycolipids containing two or more sugars. Gangliosides are the most complex class, characterized by a branched oligosaccharide chain that contains at least one sialic acid residue. Therefore, the statement claiming that gangliosides lack sialic acid is incorrect.

191. (A) Cholesterol 7-alpha-hydroxylase
The synthesis of primary bile acids from cholesterol is a tightly regulated metabolic pathway in the liver. The rate-limiting step is the first reaction, which is catalyzed by the enzyme cholesterol 7-alpha-hydroxylase. this cytochrome P450 enzyme adds a hydroxyl group to the C-7 position of the cholesterol nucleus. The activity of this enzyme is regulated by a feedback mechanism sensitive to the levels of bile acids returning to the liver.

192. (C) Non-steroidal anti-inflammatory drugs (NSAIDs)
Non-steroidal anti-inflammatory drugs, such as aspirin, ibuprofen, and naproxen, exert their therapeutic effects by inhibiting the cyclooxygenase enzymes (COX-1 and COX-2). These enzymes are responsible for converting arachidonic acid into prostaglandin H2, the precursor for all other prostaglandins and thromboxanes. By blocking this pathway,

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NSAIDs effectively reduce the production of these mediators, thereby decreasing inflammation, alleviating pain, and lowering fever in various clinical conditions.

193. (B) Extract low-MW sugars; precipitate proteins/polysaccharides
In the analysis of plant carbohydrates, hot 80% aqueous ethanol is frequently used as a selective extraction solvent. At this concentration, low-molecular-weight sugars, such as glucose, fructose, and sucrose, are highly soluble and can be easily recovered. Simultaneously, the ethanol causes the denaturation and precipitation of proteins and large structural or storage polysaccharides like starch. This separation is crucial for the accurate quantification of simple soluble sugars without interference from complex polymers.

194. (B) Forms a stable molybdenum blue complex with Cu2O
The Nelson-Somogyi method is a colorimetric assay for reducing sugars. In the first stage, the sugar reduces alkaline cupric ions to cuprous oxide (Cu2O). The arsenomolybdate reagent is then added, which reacts with the cuprous oxide. This reaction results in the reduction of molybdenum within the reagent, forming a stable, intensely blue-colored complex known as molybdenum blue. The absorbance of this blue color is then measured to quantify the sugar.

195. (A) Both A and R are true and R is the correct explanation of A.
The acid value is a vital quality parameter for edible oils, representing the quantity of free fatty acids present. In high-quality, refined oils, the acid value should be very low. Free fatty acids are typically released from triacylglycerols through hydrolysis caused by heat, moisture, or microbial activity. A low value confirms that the oil has not undergone significant hydrolytic degradation, ensuring better stability, taste, and safety for human consumption.

196. (A) Polarity differences and silica gel interactions
Thin-layer chromatography separates lipids based on the differential partitioning of molecules between the mobile solvent phase and the stationary silica gel phase. Silica gel is highly polar and forms hydrogen bonds with the polar functional groups of lipids. Consequently, polar lipids like phospholipids are strongly retained and migrate slowly. Non-polar lipids, such as triacylglycerols, interact weakly with the silica and migrate further up the plate, resulting in distinct spots.

197. (B) D-galactose
Epimers are sugars that differ in their configuration at only one specific chiral carbon atom. D-glucose and D-galactose are a classic pair of C-4 epimers. They have identical chemical structures except for the orientation of the hydroxyl group at the fourth carbon atom. In D-glucose, the C-4 hydroxyl is oriented to one side, while in D-galactose, it is oriented to the opposite side, resulting in different biological properties and metabolic pathways.

198. (C) Polarimeter
A polarimeter is a specialized scientific instrument used to measure the angle by which the plane of polarized light is rotated as it passes through an optically active substance. In carbohydrate analysis, this measurement is used to determine the specific rotation of a sugar in solution. This value is characteristic for each sugar and is used to identify the substance, check its purity, and monitor processes like mutarotation or enzymatic hydrolysis.

199. (C) Starch
Maltose, also known as malt sugar, is a disaccharide consisting of two glucose units linked by an alpha-1,4-glycosidic bond. It is produced biologically during the enzymatic breakdown of starch, a process catalyzed by amylases. This occurs in the human digestive system and during the germination of seeds (malting). In these processes, large starch molecules are hydrolyzed into smaller units, with maltose being one of the primary intermediate products formed.

200. (B) I, III and IV
Glycogen is the primary glucose storage polymer in animals, found mainly in the liver and skeletal muscles. Structurally, it is more highly branched than amylopectin, which increases its solubility and mobilization rate. Like amylopectin, it reacts with iodine to produce a characteristic red-violet or brownish color. Its breakdown is regulated by the enzyme glycogen phosphorylase, which removes glucose units from the non-reducing ends of the polymer chains.

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201. (B) Intramolecular hydrogen bonds between adjacent units
Cellulose is a linear polysaccharide composed of D-glucose units connected by beta-1,4-glycosidic bonds. This specific linkage allows the chain to adopt a flat, ribbon-like structure. The rigidity of this structure is maintained by extensive intramolecular hydrogen bonds between the hydroxyl groups of adjacent glucose monomers. These bonds prevent the chain from coiling, facilitating the alignment of multiple chains into the tough, insoluble microfibrils that provide structural support to plant cell walls.

202. (B) Antithrombin III
Heparin is a naturally occurring anticoagulant that prevents blood clots from forming in the body. It works by binding to and significantly enhancing the activity of antithrombin III, a circulating plasma protein that inhibits several serine proteases in the coagulation cascade. Once activated by heparin, antithrombin III rapidly inactivates thrombin and Factor Xa, effectively halting the clotting process. This mechanism is the basis for heparin's widespread use in clinical medicine.

203. (B) Sequence and terminal sugar of the oligosaccharide
The biological specificity of the ABO blood groups is determined by the exact structure of the oligosaccharide chains attached to the surface of red blood cells. All individuals possess the H-antigen precursor. The blood type is defined by which specific terminal sugar is added to this precursor: N-acetylgalactosamine for type A, galactose for type B, and neither for type O. These terminal sugars serve as the unique epitopes recognized by antibodies.

204. (C) Lipid A
Lipopolysaccharide (LPS) is a complex molecule found in the outer membrane of Gram-negative bacteria and is responsible for many of the symptoms of bacterial infection. The toxic component of LPS is Lipid A, the hydrophobic portion that anchors the molecule into the membrane. When bacteria die or multiply, Lipid A is released, triggering a massive immune response that can lead to fever, inflammation, and life-threatening endotoxic shock.

205. (A) P-2, Q-1, R-3, S-4
Different saccharides are characterized by specific glycosidic linkages. Amylose is a linear glucose polymer with alpha-1,4 bonds. Cellulose is a structural polymer with beta-1,4 linkages that provide rigidity. Sucrose is a unique disaccharide with an alpha-1,2 linkage between glucose and fructose. In amylopectin and glycogen, the linear chains are connected by alpha-1,4 bonds, while the branch points are formed by alpha-1,6-glycosidic linkages.

206. (B) Linoleic acid
Omega-6 fatty acids are a family of polyunsaturated fatty acids characterized by a double bond at the sixth carbon position from the methyl end. The primary precursor for this family is linoleic acid, an essential 18-carbon fatty acid. In the body, linoleic acid can be further elongated and desaturated to form other omega-6 fatty acids, most notably arachidonic acid, which serves as a precursor for numerous pro-inflammatory and regulatory signaling molecules.

207. (B) Autoxidation and development of rancidity
Hydrogenation is a chemical process that adds hydrogen to the double bonds of unsaturated fatty acids in vegetable oils. By reducing the number of double bonds, this process not only raises the melting point to create solid fats like margarine but also increases the oil's stability. Saturated bonds are much less reactive with oxygen, thereby preventing the autoxidation process that leads to the development of unpleasant flavors and odors associated with rancidity.

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208. (B) sn-1 and sn-3 positions
Pancreatic lipase is the primary enzyme involved in the digestion of triacylglycerols in the small intestine. It exhibits high positional specificity, selectively hydrolyzing the ester bonds at the primary positions of the glycerol backbone, specifically the sn-1 and sn-3 positions. This enzymatic action results in the release of two free fatty acids and the formation of a 2-monoacylglycerol, which are the main products absorbed by the intestinal enterocytes.

209. (B) Permanent positive charge (quaternary ammonium group)
Phosphatidylcholine is a major structural phospholipid that contains a choline head

group. Choline is an organic compound with a quaternary ammonium group, which means the nitrogen atom is bonded to four other groups and carries a permanent positive charge regardless of the surrounding pH. This positive charge, combined with the negative charge on the phosphate group, gives the head group a zwitterionic character, influencing the lipid's interaction within the membrane.

210. (B) IV only
Sphingolipids are a diverse class of lipids characterized by a sphingosine backbone. Ceramides consist of sphingosine and a fatty acid, while sphingomyelin adds a phosphate-linked head group. Cerebrosides are simple glycolipids that contain a single sugar residue, such as glucose or galactose, linked to the ceramide. Therefore, the statement that cerebrosides contain a complex, highly branched oligosaccharide is incorrect, as that description applies to gangliosides.

211. (B) Contain one or more sialic acid residues
Both gangliosides and globosides are glycosphingolipids, but they are distinguished by the composition of their carbohydrate chains. Globosides are neutral glycolipids that contain two or more sugar residues. Gangliosides are more complex and are acidic because they contain one or more sialic acid residues (such as N-acetylneuraminic acid). These sialic acid groups provide gangliosides with a negative charge at physiological pH, which is critical for their biological functions.

212. (B) Galactolipids and Sulfolipids (SQDG)
In plants, phosphorus is a vital nutrient, and its scarcity can limit growth. To adapt to phosphate starvation, plants initiate a process of lipid remodeling in their membranes. They degrade phospholipids and significantly upregulate the biosynthesis of phosphorus-free lipids, specifically galactolipids (like MGDG and DGDG) and sulfolipids (SQDG). These non-phosphorus lipids can substitute for phospholipids in the chloroplast membranes, allowing the plant to redirect limited phosphate toward DNA and RNA synthesis.

213. (B) Squalene
The biosynthesis of sterols is a complex pathway that begins with acetyl-CoA and proceeds through isoprene units. A critical intermediate in this pathway is squalene, a 30-carbon linear hydrocarbon. Squalene is formed by the condensation of two farnesyl pyrophosphate molecules. In a key regulatory step, squalene undergoes enzymatic epoxidation and then a spectacular cyclization reaction to form lanosterol, the first polycyclic precursor with the characteristic four-ring steroid nucleus.

214. (A) Dehydroxylation of primary bile acids by bacteria
Primary bile acids are synthesized in the liver and secreted into the intestine to aid in lipid digestion. Once they reach the colon, they are modified by anaerobic bacteria. The bacteria perform dehydroxylation at the C-7 position, converting cholic acid into deoxycholic acid and chenodeoxycholic acid into lithocholic acid. These products are known as secondary bile acids. Some are excreted in the feces, while others are reabsorbed and returned to the liver.

215. (A) Both A and R are true and R is the correct explanation of A.
Prostaglandins are potent lipid mediators that function differently than classical endocrine hormones. They usually act in an autocrine or paracrine manner, affecting only the cells that synthesized them or those in the immediate vicinity. This localized action is necessary because prostaglandins are chemically unstable and are very rapidly inactivated by enzymes in the tissues and the systemic circulation, preventing them from exerting effects at distant sites in the body.

216. (A) Phenol-sulfuric acid method
The phenol-sulfuric acid method is a quantitative technique for estimating the total carbohydrate concentration in a sample. The addition of concentrated sulfuric acid generates heat and highly acidic conditions that hydrolyze all glycosidic bonds in oligo- and polysaccharides. The acid then dehydrates the resulting monosaccharides into furfural or hydroxymethylfurfural. These reactive intermediates then combine with phenol to form a stable colored product, allowing for the direct measurement of all sugars.

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217. (B) A ketohexose like fructose
Seliwanoff's test is a rapid qualitative assay used to distinguish ketoses from aldoses. The reagent contains resorcinol and concentrated

hydrochloric acid. Ketoses, such as fructose, undergo acid-catalyzed dehydration much more quickly than aldoses to form furfural derivatives. These derivatives then react with resorcinol to produce a characteristic deep cherry-red color within a very short time (1-2 minutes) of heating. Aldoses may eventually produce a similar color, but only after prolonged heating.

218. (A) Predominantly composed of saturated fatty acids
The iodine value is a measure of the total degree of unsaturation in a fat, reflecting the number of double bonds available to react with iodine. Coconut oil is known for having an extremely low iodine value, which indicates that it contains very few double bonds. This confirms that the oil is predominantly composed of saturated fatty acids, such as lauric and myristic acid, which makes it highly resistant to oxidation and solid at room temperature.

219. (C) Achieve optimal biphasic system separation
The Bligh-Dyer lipid extraction method relies on a precisely balanced ratio of chloroform, methanol, and water. Initially, these solvents are proportioned to form a single, homogenous phase that efficiently extracts lipids from the tissue sample. The addition of more water or chloroform then shifts the solvent balance, causing the mixture to partition into two distinct layers. This biphasic separation is essential for isolating the lipids in the lower chloroform phase from water-soluble contaminants.

220. (A) I, II and IV
Gas chromatography (GC) is a powerful tool for analyzing the fatty acid composition of lipids. Before analysis, lipids are converted to fatty acid methyl esters (FAMEs) to increase their volatility and thermal stability. The FAMEs are separated using capillary columns based on their chain length and unsaturation, which directly influence their retention times. Detection is typically achieved using a flame ionization detector (FID), which provides high sensitivity and a broad linear response for lipid quantification.

221. (A) D-Mannose
Epimers are stereoisomers that differ in the configuration of the hydroxyl group at only one specific chiral center. D-glucose and D-mannose are a well-known pair of C-2 epimers. They have the same molecular formula and structure, except for the orientation of the hydroxyl group at the second carbon atom. Similarly, D-glucose and D-galactose are C-4 epimers. D-fructose, however, is a functional isomer of glucose as it contains a ketone group.

222. (B) D-glucopyranose
Glucose is the primary sugar used for energy by the human body and is transported through the bloodstream. While it can exist in several forms, the most stable and predominant configuration in physiological conditions is the D-isomer in a six-membered pyranose ring. Specifically, a mixture of the alpha and beta anomers of D-glucopyranose exists in solution. The D-designation refers to the configuration of the chiral center furthest from the carbonyl group.

223. (A) Fail to exhibit mutarotation in aqueous solution
Mutarotation is the spontaneous change in the optical rotation of a sugar solution as the cyclic anomers interconvert through an open-chain form. This process requires a free anomeric carbon that can revert to an aldehyde or ketone. In sucrose, the glycosidic bond links the anomeric carbons of both glucose and fructose. Because these reactive centers are locked, sucrose cannot open into a linear form, making it a non-reducing sugar that lacks mutarotation.

224. (B) An alpha,alpha-1,1 linkage between two glucose molecules
Trehalose is a disaccharide consisting of two D-glucose units. It is uniquely structured with an alpha,alpha-1,1-glycosidic linkage, which connects the anomeric carbon (C-1) of one glucose unit to the anomeric carbon (C-1) of the other. Because both reducing ends are involved in the bond, the molecule has no free reactive aldehyde group. This makes trehalose a non-reducing sugar, contributing to its exceptional stability under high temperatures and desiccating conditions.

225. (A) P-2, Q-3, R-1, S-4
Polysaccharides are defined by their specific glycosidic linkages. Amylose is a linear starch component with alpha-1,4-glucose bonds. Cellulose is a linear structural polymer with beta-1,4-glucose bonds, providing high rigidity. Chitin is similar to cellulose but consists of beta-1,4-linked N-acetylglucosamine units. Amylopectin

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and glycogen consist of linear alpha-1,4 chains but are branched via alpha-1,6-glycosidic linkages, which are found at the branch points.

226. (A) Shorter chains and a higher degree of branching
Both glycogen and amylopectin are branched polymers of glucose, but glycogen is much more compact and soluble. This is due to its higher frequency of branching; glycogen has branches every 8 to 12 residues, compared to 24 to 30 residues in amylopectin. These shorter chains and frequent branches prevent the polymer from forming the large crystalline aggregates seen in starch, allowing glycogen to be stored efficiently in the cytosol while remaining highly accessible.

227. (A) Glucuronic acid
Hyaluronic acid is a high-molecular-weight, non-sulfated glycosaminoglycan found in connective, epithelial, and neural tissues. Its structure consists of a repeating disaccharide unit composed of D-glucuronic acid and N-acetyl-D-glucosamine. These units are linked by alternating beta-1,3 and beta-1,4-glycosidic bonds. The carboxyl groups of the glucuronic acid residues are negatively charged at physiological pH, allowing the molecule to attract water and provide lubrication and shock absorption in joints.

228. (A) The highly variable O-antigen chain
Lipopolysaccharides (LPS) are complex glycolipids in the outer membrane of Gram-negative bacteria. The structure includes Lipid A, a core oligosaccharide, and the O-antigen. The O-antigen is the outermost portion, consisting of repeating oligosaccharide units. This region is extremely diverse, with significant variations in sugar composition and sequence between different bacterial strains. This diversity determines the serological specificity of the bacteria and allows them to evade the host's immune system.

229. (A) Cis configuration
Naturally occurring unsaturated fatty acids in biological systems almost always contain double bonds in the cis configuration. In this arrangement, the hydrogen atoms attached to the double-bonded carbons are on the same side. This creates a rigid "kink" or bend in the hydrocarbon chain. These kinks prevent the fatty acids from packing tightly together in membranes, which is essential for maintaining proper membrane fluidity and functionality across different temperatures.

230. (C) I only
The melting point of saturated fatty acids is determined by the strength of the van der Waals interactions between the molecules. As the carbon chain length increases, the surface area for these interactions also increases, requiring more energy to melt the substance. Therefore, the melting point increases with chain length. The other statements are correct: unsaturation increases oxidation risk, and trans fats pack more tightly than their bent cis counterparts.

231. (A) Yield twice energy of carbohydrates and are anhydrous
Triacylglycerols are the most efficient molecules for long-term energy storage. Because their fatty acids are more highly reduced than the carbons in sugars, they yield significantly more energy (9 kcal/g) upon oxidation compared to glycogen (4 kcal/g). Additionally, triacylglycerols are hydrophobic and stored in an anhydrous state. In contrast, glycogen is polar and requires a large amount of water for hydration, making triacylglycerols far lighter per unit of stored energy.

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232. (A) IP3 and Diacylglycerol (DAG)
Phosphatidylinositol 4,5-bisphosphate (PIP2) is a key phospholipid involved in cell signaling. In response to certain hormonal signals, the enzyme phospholipase C catalyzes the hydrolysis of PIP2. This reaction produces two critical second messengers: inositol 1,4,5-trisphosphate (IP3) and diacylglycerol (DAG). IP3 is water-soluble and diffuses to the endoplasmic reticulum to release stored calcium ions, while DAG remains in the membrane to activate protein kinase C, triggering various cellular responses.

233. (A) Palmitoyl-CoA and Serine
The biosynthesis of sphingosine, the 18-carbon amino alcohol backbone of all sphingolipids, begins with the condensation of two specific precursors. The process starts in the endoplasmic reticulum, where the enzyme serine palmitoyltransferase catalyzes the reaction between the 16-carbon fatty acid derivative palmitoyl-CoA and the amino acid serine. This initial condensation is the rate-limiting step in the synthesis of sphingolipids, eventually leading

to the formation of ceramide through several subsequent enzymatic stages.

234. (A) Monogalactosyldiacylglycerol (MGDG)
In the photosynthetic thylakoid membranes of plants and algae, galactolipids are the most abundant class of lipids, vastly outnumbering phospholipids. The most prominent of these is monogalactosyldiacylglycerol (MGDG), which consists of a single galactose sugar linked to a diacylglycerol backbone. MGDG possesses a non-bilayer-forming conical shape that is essential for the proper packing and functioning of the light-harvesting protein complexes within the membrane, facilitating efficient energy transfer during photosynthesis.

235. (A) The five-carbon isoprene unit (IPP)
All sterols and many other natural products, such as carotenoids and rubber, are synthesized through the isoprenoid pathway. The fundamental building block for these molecules is the five-carbon isoprene unit, specifically in the form of isopentenyl pyrophosphate (IPP). Through a series of condensation reactions, IPP units are combined to form larger chains like geranyl pyrophosphate and squalene. Squalene then undergoes cyclization to form the characteristic four-ring steroid nucleus found in cholesterol and ergosterol.

236. (A) Glycine or taurine
Bile acids are synthesized from cholesterol in the liver. Before being secreted into the bile, they undergo conjugation, a process where a primary bile acid is covalently linked to either the amino acid glycine or the sulfonic acid-containing derivative taurine. This modification significantly increases the polarity and water solubility of the bile acid at physiological pH. These conjugated bile salts are more effective detergents for emulsifying dietary fats in the aqueous environment of the small intestine.

237. (A) Phospholipase A_2
Prostaglandin synthesis is initiated in response to various inflammatory or physiological stimuli. The first and rate-limiting step is the release of arachidonic acid from the sn-2 position of membrane phospholipids. This reaction is catalyzed by the enzyme phospholipase A_2. Once released, the free arachidonic acid becomes available for the cyclooxygenase enzymes to convert it into the various prostaglandins, thromboxanes, and other eicosanoids that mediate pain, fever, and inflammation.

238. (A) Hot 80% aqueous ethanol
In the analysis of plant tissues, 80% aqueous ethanol is the preferred solvent for extracting low-molecular-weight carbohydrates, such as glucose, fructose, and sucrose. This concentration is effective because these simple sugars are highly soluble in the ethanol-water mixture. Simultaneously, the ethanol acts as a precipitating agent for proteins and large, high-molecular-weight polysaccharides like starch and cellulose. This selective extraction allows researchers to separate simple sugars from complex polymers for further quantitative analysis.

239. (A) Undergo dehydration to furfurals more rapidly than aldoses
Seliwanoff's test is a colorimetric assay used to distinguish between ketoses and aldoses. The reagent contains resorcinol and concentrated hydrochloric acid. When heated, the acid catalyzes the dehydration of sugars to form furfural or its derivatives. Ketoses, such as fructose, undergo this dehydration reaction much faster than aldoses. The resulting furfural then reacts with resorcinol to form a deep cherry-red complex. Under controlled conditions, ketoses react within minutes, while aldoses take much longer.

240. (D) I, II, III and IV
Quantitative lipid analysis involves several specific values to assess fat quality. The peroxide value measures primary oxidation, while the iodine value indicates the degree of unsaturation using reagents like Wijs solution. The acid value quantifies free fatty acids, a marker of hydrolytic rancidity. The saponification value reflects the average chain length and molecular weight of the fatty acids. All these measurements provide a comprehensive profile of the lipid's chemical state and nutritional quality.

241. (A) Iodine partitions reversibly into hydrophobic lipid spots
Iodine visualization is a common, non-destructive technique for detecting lipids on thin-layer chromatography plates. The plate is placed in a chamber containing iodine crystals, which sublimate into a vapor. The iodine vapor selectively and reversibly partitions into the non-polar, hydrophobic lipid spots, turning them

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yellow or brown against the white background of the silica gel. This allows for the identification of lipid locations without permanently altering the molecules, enabling their subsequent recovery if necessary.

242. (A) Slower than saturated fatty acids of the same length
In gas chromatography, the stationary phase of the column interacts with the analytes based on their chemical properties. When using a polar stationary phase, such as those containing polyester or cyano groups, the phase has a stronger affinity for the double bonds in unsaturated fatty acid methyl esters (FAMEs). Consequently, unsaturated FAMEs are retained longer and elute slower than saturated FAMEs of the same carbon chain length, resulting in a predictable and effective separation.

243. (A) $\approx 64\%$ beta-anomer and $\approx 36\%$ alpha-anomer
Mutarotation in D-glucose continues until a stable equilibrium is reached between the cyclic anomers. At room temperature in water, the final equilibrium mixture consists of approximately 64% of the beta-D-glucopyranose anomer and 36% of the alpha-D-glucopyranose anomer. Only a trace amount (less than 0.02%) exists in the open-chain form. The higher abundance of the beta anomer is due to its greater thermodynamic stability, as all its bulky substituents are in equatorial positions.

244. (A) Epimers
Diastereomers are stereoisomers that are not mirror images of each other. A specific subclass of diastereomers is known as epimers, which are molecules that differ in their three-dimensional configuration at only one single asymmetric (chiral) center. For example, D-glucose and D-mannose are C-2 epimers, while D-glucose and D-galactose are C-4 epimers. This difference in configuration, though small, leads to significant variations in their chemical reactivity and biological functions within the cell.

245. (A) Both A and R are true and R is the correct explanation of A.
Cellulose is a structural polysaccharide composed of glucose units linked by beta-1,4-glycosidic bonds. Unlike starch, which has alpha linkages that humans can break down using amylases, cellulose requires the specific enzyme cellulase to hydrolyze its beta linkages. Since the human digestive system does not produce cellulase, we cannot break down cellulose into glucose for energy. Instead, it passes through the gut as insoluble dietary fiber, providing bulk and supporting digestive health.

246. (A) Highly branched, with branches every 8-12 residues
Glycogen is the primary glucose storage molecule in animals, including humans. Its structure is very similar to amylopectin in starch, consisting of linear chains of alpha-1,4-linked glucose units with alpha-1,6 branch points. However, glycogen is much more highly branched, with points occurring every 8 to 12 residues. This compact, highly branched structure provides a large number of non-reducing ends, allowing enzymes like glycogen phosphorylase to rapidly release glucose during times of metabolic need.

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247. (A) Hydrogen bonding between parallel beta-1,4-linked chains
Chitin is a robust structural polysaccharide that forms the basis of the arthropod exoskeleton and fungal cell walls. It is a linear polymer of N-acetylglucosamine units connected by beta-1,4-glycosidic bonds. Like cellulose, these linear chains align in parallel to form tough fibers. The high tensile strength and rigidity of chitin arise from extensive networks of hydrogen bonds between the acetamido groups of adjacent chains, creating a highly stable and protective physical framework.

248. (A) Glucuronic acid and N-acetylgalactosamine-sulfate
Chondroitin sulfate is a member of the glycosaminoglycan family, which are essential components of the extracellular matrix. It consists of long, unbranched chains made of repeating disaccharide units. Each unit is composed of D-glucuronic acid and N-acetyl-D-galactosamine. The galactosamine residue is typically sulfated at either the C-4 or C-6 position. These highly negative sulfate groups allow the molecule to bind water, providing the osmotic pressure and resilience required for cartilage to function as a shock absorber.

249. (A) Direct precursor for A and B immunodominant sugars
The H antigen is the essential carbohydrate foundation for the ABO blood group system.

It consists of a specific oligosaccharide chain terminating in an alpha-L-fucose residue. All individuals produce this antigen, and it serves as the direct substrate for the glycosyltransferase enzymes encoded by the A and B alleles. These enzymes add specific terminal sugars to the H antigen to create the A or B antigens. Individuals with type O blood lack these enzymes, leaving the H antigen unmodified.

250. (C) I only
Bacterial cell wall structures vary significantly between species. Peptidoglycan is a fundamental component found in nearly all bacteria, and it is especially prominent in Gram-positive bacteria, where it forms a very thick, multi-layered wall. Teichoic acids are also characteristic of the Gram-positive cell wall. Lipopolysaccharides, however, are exclusively located in the outer membrane of Gram-negative bacteria. Therefore, the statement that peptidoglycan is absent in Gram-positive bacteria is fundamentally incorrect, as they contain a substantial amount of it.

251. (A) First double bonds at omega-6 and omega-3 positions
Essential fatty acids, including linoleic and alpha-linolenic acids, are polyunsaturated fats that the human body cannot produce. They are characterized by the location of their first double bond relative to the methyl (omega) end of the chain. Linoleic acid is an omega-6 fatty acid, while alpha-linolenic acid is an omega-3 fatty acid. These molecules are vital for maintaining membrane structure, skin health, and serving as precursors for the synthesis of important signaling molecules like eicosanoids.

252. (A) Increases due to reactive allylic carbons
Autoxidation is a free radical chain reaction that leads to the spoilage of fats. The reaction primarily occurs at the methylene groups located between double bonds in unsaturated fatty acids. These allylic carbons have relatively weak carbon-hydrogen bonds, making them highly susceptible to radical attack. Therefore, as the degree of unsaturation increases in a fatty acid, the number of reactive sites also increases, significantly raising the overall susceptibility of the lipid to oxidative rancidity and degradation.

253. (A) Emulsifying agents to stabilize oil-in-water mixtures
Mono- and diacylglycerols are versatile food additives widely used as emulsifiers. Unlike triacylglycerols, these molecules are amphipathic, possessing both hydrophobic fatty acid tails and one or two polar hydroxyl groups on the glycerol backbone. This dual nature allows them to orient themselves at the interface between oil and water, reducing surface tension and preventing the phases from separating. They are essential for stabilizing the texture and consistency of products like margarine, ice cream, and baked goods.

254. (A) Two phosphate groups and four fatty acyl chains
Cardiolipin, also known as diphosphatidylglycerol, is a unique and essential phospholipid found almost exclusively in the inner mitochondrial membrane. Its structure is distinctive among the glycerophospholipids because it consists of two phosphatidic acid molecules linked together by a third glycerol molecule. Consequently, cardiolipin possesses two phosphate groups and four fatty acyl chains, rather than the standard one and two. This complex structure is critical for supporting the activity of the enzymes involved in oxidative phosphorylation.

255. (B) P-3, Q-4, R-2, S-1
Sphingolipids are categorized by the molecules attached to their ceramide base. A ceramide itself consists only of sphingosine and a fatty acid. Sphingomyelin is distinguished by a phosphocholine head group. Cerebrosides are simple glycolipids with a single monosaccharide residue. Gangliosides are the most complex, featuring an oligosaccharide head group that includes at least one sialic acid residue. These variations in head group composition determine the lipid's role in membrane structure, signaling, and cellular recognition.

256. (A) Gaucher disease
Gaucher disease is a genetic lysosomal storage disorder caused by a deficiency of the enzyme beta-glucocerebrosidase. This enzyme is normally responsible for the breakdown of glucocerebroside into ceramide and glucose. When the enzyme is inactive, glucocerebroside accumulates pathologically within the lysosomes of macrophages. These enlarged, lipid-laden cells, known as Gaucher cells, accumulate in

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the liver, spleen, and bone marrow, leading to hepatosplenomegaly, anemia, and bone complications characteristic of the disease.

257. (A) An alpha-glycosidic bond
Sulfoquinovosyl diacylglycerol (SQDG) is a major sulfur-containing glycolipid found in the chloroplast membranes of all photosynthetic organisms. Structurally, it consists of a diacylglycerol moiety linked to a unique sugar called sulfoquinovose. The sugar is a derivative of glucose where the hydroxyl group at the C-6 position is replaced by a sulfonic acid group. In SQDG, this sulfoquinovose residue is specifically connected to the primary hydroxyl group of the diacylglycerol backbone through an alpha-glycosidic bond.

258. (A) Competing with dietary cholesterol for intestinal absorption
Phytosterols, such as sitosterol and campesterol, are plant-derived sterols that are structurally very similar to animal cholesterol. Because of this similarity, they can compete with dietary and biliary cholesterol for incorporation into mixed micelles in the small intestine. This competition effectively reduces the amount of cholesterol that can be absorbed by the intestinal enterocytes and transported into the bloodstream. Consequently, regular consumption of phytosterols can lead to a significant lowering of serum total and LDL cholesterol levels.

259. (A) Lack a C-7 hydroxyl due to bacterial dehydroxylation
Bile acids are modified as they move through the digestive tract. Primary bile acids, like cholic and chenodeoxycholic acid, are synthesized in the liver and possess a hydroxyl group at the C-7 position. Once they reach the colon, anaerobic bacteria perform a 7-alpha-dehydroxylation reaction. This enzymatic process removes the hydroxyl group at carbon 7, converting cholic acid into deoxycholic acid and chenodeoxycholic acid into lithocholic acid. These dehydroxylated products are classified as secondary bile acids.

260. (A) I, II and IV
The cyclooxygenase (COX) pathway is a central metabolic route for the synthesis of eicosanoids. It converts free arachidonic acid into the intermediate prostaglandin H2 through a process that involves both oxygenase and peroxidase activities. Prostaglandin H2 is then used to synthesize various prostaglandins and thromboxanes. This pathway is the primary target of non-steroidal anti-inflammatory drugs (NSAIDs), which block the enzyme to reduce pain and inflammation. Leukotrienes are not produced here; they arise from the lipoxygenase pathway.

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261. (A) TLC or solid-phase extraction using non-polar solvents
In lipid analysis, it is often necessary to separate neutral lipids from polar membrane lipids. Because neutral lipids, such as triacylglycerols and sterol esters, are highly hydrophobic, they can be selectively isolated using non-polar solvents. Techniques like thin-layer chromatography (TLC) or solid-phase extraction utilize this property. Neutral lipids will partition into a non-polar mobile phase or elute quickly from a column with a non-polar solvent, while polar lipids like phospholipids will be strongly retained by a polar stationary phase.

262. (A) 620 nm
The Anthrone method is a colorimetric assay used to determine the total concentration of carbohydrates in a sample. When carbohydrates are heated with the anthrone reagent and concentrated sulfuric acid, they form a characteristic blue-green complex. The absorbance of this colored solution is measured using a spectrophotometer, typically at a wavelength of 620 nm. The intensity of the light absorbed at this wavelength is directly proportional to the amount of sugar present, allowing for precise quantification using a standard curve.

263. (A) Highly unsaturated and largely intact (not hydrolyzed)
The iodine and acid values are important indicators of lipid quality. A high iodine value indicates a large number of double bonds, confirming that the fat or oil is highly unsaturated. A low acid value indicates that there is a minimal amount of free fatty acids present, suggesting that the triacylglycerols have not undergone significant hydrolysis. Therefore, a sample with these values is highly unsaturated and mostly intact, representing a fresh, non-degraded oil such as fresh sunflower or linseed oil.

264. (A) Methanol and an acid or base catalyst
Analyzing the fatty acid composition of triacylglycerols by gas chromatography requires their conversion into fatty acid methyl esters (FAMEs). This is achieved through a transesterification reaction, where the triglycerides react with an excess of methanol. The process requires a catalyst, such as hydrochloric acid, sulfuric acid, or sodium methoxide, to facilitate the exchange of the glycerol backbone for methyl groups. This reaction produces volatile and thermally stable FAMEs, which can be easily separated and quantified in the chromatographic system.

265. (A) Both A and R are true and R is the correct explanation of A.
Amylose is a linear polymer of D-glucose units linked by alpha-1,4-glycosidic bonds. This specific linkage geometry introduces a natural curve in the chain, causing it to spontaneously adopt a flexible, helical secondary structure when dissolved in water. This hollow helix provides a perfectly sized interior space to trap iodine molecules, forming a stable polyiodide-amylose complex. This complex absorbs visible light, resulting in the characteristic deep blue color used in the classic iodine test for starch.

266. (A) Anomerism
Anomerism is a form of stereoisomerism that occurs when a linear monosaccharide cyclizes to form a hemiacetal or hemiketal. During cyclization, the carbonyl carbon atom becomes a new asymmetric center, called the anomeric carbon. The resulting isomers, known as anomers, differ only in the spatial orientation of the hydroxyl group at this carbon atom. These are designated as alpha or beta depending on their relationship to the ring plane and the chiral center that determines the D or L series.

267. (A) Glucose unit with a free C-4 hydroxyl group
A glycogen molecule is a large, branched polymer of glucose with many ends. Because each branch is formed by an alpha-1,6 linkage, the ends of the branches contain glucose units where the C-4 hydroxyl group is not involved in a bond. These are called the non-reducing ends. These ends are biologically critical because enzymes like glycogen phosphorylase and glycogen synthase act only on these sites to remove or add glucose units, respectively, allowing for the rapid mobilization or storage of glucose.

268. (A) alpha-1,6 glycosidic bond
Amylopectin is the branched component of starch. While the main chains of the molecule consist of glucose units connected by alpha-1,4-glycosidic bonds, the characteristic branches are formed by a different linkage. An alpha-1,6-glycosidic bond connects the anomeric carbon (C-1) of a glucose unit at the start of a new branch to the sixth carbon (C-6) of a glucose unit in the existing chain. These branch points occur roughly every 24 to 30 residues, creating a complex, tree-like molecular architecture.

269. (A) Cellulose microfibrils in a hemicellulose/pectin matrix
The rigid cell wall of plants is a complex structural network that provides mechanical support and protection. Its primary framework consists of long, linear cellulose molecules organized into tough, crystalline microfibrils. These microfibrils are embedded in a highly hydrated matrix of other polysaccharides, including various hemicelluloses and pectins. Hemicelluloses cross-link the cellulose microfibrils, while pectins form a gel-like medium, together creating a composite material with high tensile strength and resistance to compression, analogous to reinforced concrete.

270. (A) I only
Glycosaminoglycans, formerly known as mucopolysaccharides, are a family of linear, unbranched polysaccharides. They are characterized by repeating disaccharide units that include an amino sugar and usually a uronic acid. They are highly negatively charged due to the presence of sulfate and carboxyl groups. While they can be part of larger proteoglycans, the polysaccharide chains themselves are always unbranched. Therefore, the statement that they are typically short, branched polymers is incorrect; they are actually very long and strictly linear.

271. (A) Terminal carbohydrate sequences on membrane lipids/proteins
The ABO blood group antigens are biochemical markers found on the surface of erythrocytes. These antigenic determinants are defined by the specific sequence and arrangement of terminal sugars in oligosaccharide chains. These glycan chains are covalently attached to either integral membrane proteins (forming glycoproteins) or to ceramide lipids (forming glycosphingolipids). The specific terminal sugar added—N-

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acetylgalactosamine for type A or galactose for type B—is what is recognized by the immune system, determining the individual's blood group and transfusion compatibility.

272. (A) Providing negative charge and regulating cation movement
Teichoic acids are significant components of the Gram-positive bacterial cell wall. These polymers, composed of glycerol or ribitol phosphate, carry numerous negative charges due to the phosphate groups. This high negative charge density contributes to the overall surface charge of the bacterium and plays a vital role in sequestering and regulating the movement of essential cations, such as magnesium (Mg2+), into the cell. Furthermore, they provide structural elasticity to the cell wall and are involved in cell growth and division.

273. (A) 22 carbons and 6 double bonds
Docosahexaenoic acid (DHA) is a highly unsaturated omega-3 fatty acid essential for brain and eye health. Its systematic name is based on its structure: "docosa-" indicates 22 carbon atoms, and "-hexaenoic" signifies the presence of six double bonds. It is designated as 22:6(omega-3). The numerous double bonds, all in the cis configuration, give the molecule a high degree of flexibility and a very low melting point, which is crucial for maintaining the fluidity of neural and retinal membranes.

274. (A) Double bond kink disrupts hydrocarbon chain packing
Naturally occurring unsaturated fatty acids usually contain cis double bonds, which introduce a permanent 30-degree bend, or "kink," in the hydrocarbon chain. Unlike straight, saturated chains, these kinked chains cannot align closely or pack together in a highly ordered, crystalline manner. This disruption reduces the strength of the van der Waals interactions between adjacent phospholipid molecules in a bilayer. As a result, the presence of cis-unsaturated fatty acids lowers the transition temperature and increases the fluidity and permeability of biological membranes.

275. (A) P-2, Q-1, R-3, S-4
Different carbohydrates are identified by specific structural features and chemical tests. Fructose is a ketose that reacts rapidly in Seliwanoff's test. Glycogen is a branched glucose polymer that forms a red-violet complex with iodine. Peptidoglycan is the unique bacterial wall component containing N-acetylmuramic acid. Trehalose is a non-reducing disaccharide where two alpha-glucose units are joined by a 1,1-linkage. Together, these properties define the identity and biological roles of these diverse saccharides in various organisms and metabolic pathways.

276. (A) Carboxyl groups of fatty acids and hydroxyls of glycerol
Triacylglycerols are synthesized through a process called esterification. In this reaction, the three hydroxyl (-OH) groups of a single glycerol molecule react with the carboxyl (-COOH) groups of three fatty acid molecules. Each reaction involves the loss of a water molecule, forming a covalent ester bond. This condensation process can attach three identical or three different fatty acids to the glycerol backbone, creating a highly hydrophobic molecule that serves as the primary form of energy storage in adipose tissue.

277. (A) Cephalin
Phosphatidylethanolamine is a major class of phospholipids found in biological membranes, particularly in the brain and nervous tissue. It is commonly referred to as cephalin. Structurally, it consists of a glycerol backbone esterified to two fatty acids and a phosphate group, with an ethanolamine molecule linked to the phosphate. While lecithin is the common name for phosphatidylcholine, cephalin is the historical and widely used synonym for phosphatidylethanolamine, representing one of the most abundant polar lipids in mammalian cells.

278. (A) It contains an amino group at C-2 and a long unsaturated chain
Sphingosine is the fundamental 18-carbon amino alcohol that serves as the backbone for all sphingolipids. Its structure is characterized by a three-carbon head portion containing hydroxyl groups at C-1 and C-3 and an amino group at the C-2 position. Attached to C-3 is a long 15-carbon hydrocarbon tail that contains a characteristic trans double bond between C-4 and C-5. The amino group at C-2 is the site where a fatty acid is attached via an amide bond to form ceramide.

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279. (A) Monosaccharide beta-glycosidically linked to ceramide
Cerebrosides are the simplest members of the glycosphingolipid family. Their structure consists of a ceramide unit—which is a sphingosine backbone with a fatty acid attached via an amide bond—and a single sugar residue. This sugar, typically glucose or galactose, is covalently connected to the primary hydroxyl group (C-1) of the sphingosine via a beta-glycosidic linkage. Because they do not contain a phosphate or a charged group, cerebrosides are neutral glycolipids and are especially prevalent in the myelin sheaths of nerve cells.

280. (A) I and II
Aminolipids are a diverse group of phosphorus-free lipids found in the membranes of certain bacteria. They are characterized by the presence of an amino group, typically from an amino acid like ornithine or lysine, but they completely lack a phosphate group. These lipids are amphipathic, possessing both polar head groups and hydrophobic tails. Their synthesis is often significantly upregulated when bacteria are grown under phosphate-limited conditions, as they allow the cell to conserve phosphate for essential nucleic acids and energy-carrying molecules like ATP.

281. (A) Three fused cyclohexane rings and one cyclopentane ring
The classic steroid nucleus, also known as the gonane or sterane skeleton, is the fundamental polycyclic structure shared by all sterols, bile acids, and steroid hormones. It consists of seventeen carbon atoms arranged into four fused rings. Specifically, it features three six-membered cyclohexane rings (designated as A, B, and C) and one five-membered cyclopentane ring (designated as D). This rigid, planar nucleus provides a stable framework that can be modified with various side chains and functional groups to produce diverse biologically active molecules.

282. (A) Cholic acid
Primary bile acids are synthesized from cholesterol in the liver and are the main components of bile that facilitate lipid digestion. In humans, the most abundant and major primary bile acid is cholic acid. It is characterized by having three hydroxyl groups at the C-3, C-7, and C-12 positions and a carboxylated side chain. Along with chenodeoxycholic acid, cholic acid is conjugated with glycine or taurine before secretion into the gallbladder, where it acts as a powerful emulsifier for dietary fats in the intestine.

283. (A) Potent, short-lived local mediators
Prostaglandins are a family of eicosanoid signaling molecules derived from arachidonic acid. Unlike endocrine hormones that travel through the blood to distant organs, prostaglandins function primarily as local mediators. They act in an autocrine or paracrine fashion, affecting the cells that produced them or those nearby. Because they are chemically unstable and rapidly deactivated by enzymes in tissues, they have a very short biological half-life. This localized action is crucial for mediating responses like pain, inflammation, and smooth muscle contraction at specific sites of injury.

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284. (A) A non-polar solvent like petroleum ether or hexane
The Soxhlet extraction method is a standard laboratory procedure used to isolate lipids from solid samples, such as food or plant tissues. The process involves continuous cycles of solvent vaporization and condensation, where the liquid solvent percolates through the sample. To effectively extract non-polar lipids like triacylglycerols and waxes, a non-polar organic solvent is used, most commonly petroleum ether or hexane. These solvents efficiently dissolve the hydrophobic lipid molecules while leaving behind more polar substances like proteins and carbohydrates, resulting in a concentrated lipid extract for further analysis.

285. (A) Both A and R are true and R is the correct explanation of A.
The Nelson-Somogyi method is a highly specific colorimetric assay for measuring the concentration of reducing sugars in a solution. Its specificity arises from the requirement of a free anomeric carbon atom. Reducing sugars possess a free aldehyde or ketone group in their open-chain form, which can reduce cupric ions to cuprous oxide. Non-reducing sugars, like sucrose or trehalose, have their anomeric carbons locked in glycosidic bonds, preventing them from reacting with the copper reagent. Thus, only sugars with reducing potential are detected by this assay.

286. (A) Inverse relationship to average fatty acid MW
The saponification number of a fat or oil is defined as the milligrams of potassium hydroxide (KOH) required to completely saponify one gram of the substance. Each triacylglycerol molecule reacts with exactly three molecules of KOH. Therefore, one gram of a fat composed of short-chain (lower molecular weight) fatty acids will contain more total molecules than one gram of a fat composed of long-chain fatty acids. Consequently, the saponification number is inversely proportional to the average molecular weight of the fatty acids present in the lipid sample.

287. (A) Phosphatidylcholine
In thin-layer chromatography (TLC) on silica gel, the separation of lipids is based on their relative polarities. Silica gel is a polar stationary phase that interacts strongly with polar functional groups. Phosphatidylcholine is a phospholipid with a highly polar, charged zwitterionic head group. In a standard non-polar solvent system (like hexane/ether/acetic acid), this polarity causes it to bind tightly to the silica gel, resulting in the lowest R_f value among common lipids. Non-polar lipids like triacylglycerols and cholesteryl esters interact weakly and migrate much further up the plate.

288. (A) Two
An aldotetrose is a four-carbon monosaccharide that contains an aldehyde group at the C-1 position. In its linear, open-chain form, the carbon atoms at positions 2 and 3 are each bonded to four different chemical groups (a hydrogen, a hydroxyl, and two different carbon-containing groups). Therefore, these two carbons are asymmetric, or chiral, centers. Because there are two chiral centers, an aldotetrose can exist as four different stereoisomers (2 to the power of 2), which include enantiomeric pairs such as D- and L-erythrose and D- and L-threose.

289. (A) Reducing sugar anomer reaches equilibrium with other anomer
Mutarotation is the spontaneous change in the specific optical rotation of a freshly prepared solution of a reducing sugar until a stable equilibrium is reached. This occurs because the alpha and beta cyclic anomers of the sugar are in dynamic equilibrium with each other via a trace amount of the open-chain form. Each anomer has a different rotation; for example, alpha-D-glucose and beta-D-glucose rotate light differently. Over time, the molecules interconvert until the solution reaches a constant rotation value that represents the specific ratio of anomers for that sugar.

290. (A) III only
Oligo- and polysaccharides serve essential structural and energy roles across different kingdoms. Maltose is a reducing disaccharide, and trehalose functions as a vital stress protectant in many insects and fungi. Cellulose microfibrils are the primary structural component providing rigidity to plant cell walls. However, glycogen is not synthesized in plants; it is exclusively the storage form of glucose in animals and certain fungi. Plants utilize starch (amylose and amylopectin) as their primary glucose storage polymer. Therefore, the statement that glycogen is synthesized in plants is incorrect.

291. (A) Starch
Starch is the primary storage polysaccharide in plants and is composed of two distinct glucose polymers: amylose and amylopectin. Amylose is a linear molecule consisting of glucose units linked by alpha-1,4-glycosidic bonds, which forms a helical structure in water. Amylopectin, however, is a branched polymer; it contains the same alpha-1,4 linear chains but also features alpha-1,6-glycosidic linkages at branch points occurring every 24 to 30 residues. Together, these two forms are organized into semi-crystalline granules that serve as a concentrated and accessible energy reserve for the plant.

292. (A) C-2 hydroxyl of glucose replaced by N-acetylamino group
Chitin and cellulose are both linear structural polysaccharides composed of beta-1,4-linked sugar monomers, but they differ in the chemical identity of their units. In cellulose, the monomer is D-glucose. In chitin, the monomer is N-acetyl-D-glucosamine. This means that the hydroxyl (-OH) group at the C-2 position of the glucose ring in cellulose is replaced by an N-acetylamino (-NHCOCH3) group in chitin. This modification increases the opportunity for hydrogen bonding between adjacent chains, resulting in a tougher and more water-resistant material, suitable for the exoskeletons of arthropods.

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293. (A) Activating antithrombin III to inhibit thrombin
Heparin is a highly sulfated glycosaminoglycan that serves as a powerful natural and clinical anticoagulant. Its primary mechanism of action involves binding to antithrombin III, a plasma protein that naturally inhibits several enzymes in the blood coagulation cascade. When heparin binds to antithrombin III, it induces a conformational change that increases the inhibitor's affinity for its targets, particularly thrombin and Factor Xa, by several thousand-fold. This rapid inactivation of key clotting factors effectively prevents the formation of fibrin clots and halts the progression of thrombosis in the bloodstream.

294. (A) N-Acetylgalactosamine
The ABO blood group system is defined by the presence of specific carbohydrate antigens on the surface of red blood cells. All individuals produce the basic H antigen, which terminates in a fucose residue. Individuals with blood type A possess a specific glycosyltransferase enzyme (A-transferase) encoded by the A allele. This enzyme catalyzes the addition of an N-acetylgalactosamine (GalNAc) residue to the terminal galactose of the H antigen. This terminal GalNAc serves as the immunodominant sugar that characterizes the A antigen, making it distinct from the B antigen (which has galactose) and the O antigen.

295. (A) P-4, Q-2, R-3, S-1
Lipids are categorized by their diverse structural and biological characteristics. Essential fatty acids, like linoleic and linolenic acid, are those that mammals cannot synthesize themselves and must be obtained from the diet. Trans fatty acids are often formed as unintended byproducts during the industrial partial hydrogenation of vegetable oils. Sphingomyelin is a specialized membrane lipid composed of a ceramide backbone and a phosphocholine headgroup. Primary bile acids, such as cholic acid, are important detergents synthesized directly from cholesterol in the liver to aid in the digestion of dietary fats.

296. (A) Cis, with double bonds separated by a methylene group
In biological systems, naturally occurring polyunsaturated fatty acids (PUFAs) exhibit a consistent geometric and structural pattern. The double bonds are almost exclusively in the cis configuration, which introduces specific bends in the hydrocarbon chain. Furthermore, these double bonds are not conjugated; they are typically "methylene-interrupted," meaning each double bond is separated from the next by a single methylene (-CH2-) group. This unique structure is essential for the fluidity and functionality of cell membranes and is a key feature of the essential omega-3 and omega-6 fatty acids required for various metabolic signaling pathways.

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297. (A) Have high proportions of polyunsaturated fatty acids
Oxidative rancidity is a chemical degradation process that occurs when oxygen reacts with the double bonds in fatty acid chains. Polyunsaturated fatty acids (PUFAs) are particularly susceptible to this process because they contain multiple double bonds, with highly reactive methylene groups located between them. These sites are easily attacked by free radicals, initiating a chain reaction that produces hydroperoxides and subsequently volatile, malodorous compounds like aldehydes and ketones. Consequently, fats and oils with a high PUFA content, such as fish oil or certain vegetable oils, require careful storage and antioxidants to prevent spoilage.

298. (A) Yield twice energy of carbohydrates and are anhydrous
Triacylglycerols are the ideal molecules for long-term energy storage in animals for two primary chemical reasons. First, because the carbon atoms in fatty acids are more highly reduced than those in sugars, their oxidation yields more than twice as much energy (roughly 9 kcal/g) as the oxidation of carbohydrates (4 kcal/g). Second, triacylglycerols are hydrophobic and non-polar, so they are stored in a compact, anhydrous (water-free) state. In contrast, glycogen is polar and requires significant amounts of water for hydration, which would add prohibitive weight to the organism's energy reserves.

299. (A) Unsaturated fatty acid like oleic or arachidonic
In the structure of glycerophospholipids, which are the main building blocks of biological membranes, the distribution of fatty acids on the glycerol backbone is highly non-random. The sn-1 position is typically esterified with a saturated fatty acid, such as palmitic or stearic acid. In contrast, the sn-2 position is predominantly occupied by an unsaturated fatty

acid, such as oleic, linoleic, or arachidonic acid. This specific arrangement is crucial because it determines the physical properties of the membrane, such as its fluidity, and also provides a source of polyunsaturated precursors for signaling molecules like eicosanoids.

300. (C) Glycerol backbone and one fatty acid tail
In sphingolipids, the sphingosine molecule acts as the structural foundation, providing both the three-carbon backbone and one of the long hydrocarbon tails. This makes it structurally analogous to the combination of the glycerol backbone and one esterified fatty acid in triacylglycerols. The remaining fatty acid in ceramide is attached via an amide linkage to the sphingosine. (59 words)

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CHAPTER 03
Amino Acids

2021

1. Which configuration of standard amino acids is predominantly found in naturally occurring proteins?
(A) Exclusively L-configuration
(B) Both D- and L- configurations equally
(C) Exclusively D-configuration
(D) Racemic mixtures

2019

2. The chirality of an amino acid is determined by the presence of four different groups attached to the alpha-carbon. Which standard amino acid lacks a chiral center?
(A) Alanine
(B) Valine
(C) Glycine
(D) Leucine

2018

3. What structural feature is primarily responsible for the optical activity of amino acids?
(A) Presence of an asymmetric alpha-carbon
(B) Presence of a terminal side-chain carboxyl group
(C) Amphoteric nature of the molecule in solution
(D) Ability to form zwitterions at physiological pH

2021

4. Identify the incorrect statement regarding the D- and L- configurations of amino acids.
(A) D-amino acids are found in some bacterial cell walls.
(B) The D- and L- nomenclature is based on the absolute configuration of glyceraldehyde.
(C) The alpha-carbon is the stereocenter for standard amino acids.
(D) All L-amino acids are dextrorotatory (+).

2021

5. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Most naturally occurring amino acids in proteins are L-amino acids.
Reason (R): The enzymes involved in protein synthesis are stereospecific and only recognize the L-enantiomers.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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2003

6. If a new protein is discovered that incorporates D-amino acids, what is the most likely source or mechanism of its synthesis?
(A) Ribosomal protein synthesis using D-aminoacyl-tRNA
(B) Post-translational modification of L-amino acids by kinase enzymes
(C) Non-ribosomal peptide synthesis
(D) Spontaneous racemization during translation

2001

7. Which of the following amino acids is classified as having a polar, uncharged R-group at physiological pH?
(A) Aspartate
(B) Leucine
(C) Lysine
(D) Serine

2022

8. Comparing the aromatic amino acids, which one has the highest UV absorbance at 280 nm?
(A) Tryptophan
(B) Phenylalanine
(C) Tyrosine
(D) Histidine

2015

9. Based on the classification of R-group properties, which pair of amino acids would most likely be found in the hydrophobic interior of a globular protein?
(A) Arginine and Lysine
(B) Valine and Isoleucine
(C) Serine and Threonine
(D) Glutamate and Aspartate

2019

10. Match the amino acid in List I with its R-group property in List II.
List I: (Amino Acid)
P. Arginine
Q. Phenylalanine
R. Aspartate
S. Threonine
List II: (R-group Property)
1. Acidic
2. Polar, uncharged
3. Basic
4. Aromatic, non-polar
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2003

11. Which of the following amino acids contains a thioether linkage in its side chain?
(A) Methionine
(B) Cysteine
(C) Serine
(D) Threonine

2001

12. Histidine is considered uniquely important in enzyme active sites primarily due to which property?
(A) Ability to form strong covalent disulfide bonds
(B) Strong hydrophobic character of the imidazole ring
(C) Side-chain pKa near physiological pH
(D) Capacity to absorb ultraviolet light at 280 nm

2019

13. Which of the following defines a conditionally essential amino acid?
(A) Amino acid that cannot be synthesized endogenously by the body
(B) Amino acid that is only required by the body during childhood
(C) Amino acid derived solely from the consumption of plant foods
(D) Amino acid synthesized normally but required during stress

2024

14. Which statement correctly identifies an essential amino acid in human nutrition?
(A) Alanine
(B) Asparagine
(C) Tryptophan
(D) Glutamine

2007

15. Consider the following statements about nutritional classification of amino acids:
I. Leucine and Lysine are strictly ketogenic amino acids.
II. Tyrosine is an essential amino acid synthesized from Phenylalanine.
III. Arginine is essential for infants but not for healthy adults.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2021

16. What is the metabolic significance of non-essential amino acids?
(A) Absence of requirement for the process of protein synthesis
(B) Absence of amino groups preventing transamination reactions
(C) Degradation yielding exclusively ketone bodies as products
(D) Endogenous synthesis from metabolic intermediates

2018

17. Which of the following pairs is an incorrect match regarding nutritional classification?
(A) Phenylalanine - Non-essential
(B) Isoleucine - Essential
(C) Proline - Non-essential
(D) Methionine - Essential

2015

18. A zwitterion of an amino acid is best described as a molecule that:
(A) Molecular state containing only positive electrical charges
(B) Molecular state containing only negative electrical charges
(C) Net zero charge with localized positive and negative charges
(D) Molecules existing exclusively in non-aqueous environments

2012

19. At a pH below its isoelectric point (pI), an amino acid will predominantly exist as a:
(A) Cation migrating towards the cathode
(B) Anion migrating towards the anode
(C) Zwitterion remaining stationary
(D) Neutral uncharged molecule

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2001

20. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The titration curve of glycine shows two distinct buffering regions.
Reason (R): Glycine possesses an ionizable side chain in addition to its alpha-amino and alpha-carboxyl groups.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

21. For an amino acid with a neutral R-group, the isoelectric point (pI) is calculated by:
(A) The sum of pK_1 and pK_2
(B) The average of pK_1 and pK_2
(C) The difference between pK_1 and pK_2
(D) Taking the negative logarithm of pK_1

2014

22. What is the predominant ionic form of Glutamate at pH 7.4?
(A) Net positive charge (+1)
(B) Net charge of zero
(C) Net negative charge (-1)
(D) Net negative charge (-2)

2007

23. Which of the following modifications best describes the formation of hydroxyproline?
(A) Pre-translational enzymatic addition of a hydroxyl group
(B) Co-translational proteolytic cleavage of the polypeptide
(C) Spontaneous oxidation of proline in the presence of oxygen
(D) Post-translational hydroxylation requiring Vitamin C

2018

24. Selenocysteine is distinct from standard amino acids because it:
(A) Co-translational incorporation via a recoded stop codon
(B) Formation by post-translational modification of serine residues
(C) Presence of a sulfur atom maintained in a fully reduced state
(D) Inability to participate directly in enzyme active site catalysis

NODIA

2017

25. Match the modified amino acid in List I with its biological role/context in List II.
List I: (Modified Amino Acid)
P. Gamma-carboxyglutamate
Q. Hydroxyproline
R. Pyrrolysine
S. Selenocysteine
List II: (Role/Context)
1. Present in methanogenic archaea enzymes
2. Stabilization of collagen triple helix
3. Blood coagulation factors (e.g., prothrombin)
4. Glutathione peroxidase active site
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-4, R-3, S-2

2010

26. Which of the following non-standard amino acids functions as a critical neurotransmitter in the mammalian central nervous system?
(A) Pyrrolysine
(B) Gamma-aminobutyric acid (GABA)
(C) Hydroxylysine
(D) Selenomethionine

2006

27. Identify the incorrect statement concerning gamma-carboxyglutamate.
(A) It is heavily concentrated in the protein collagen.
(B) It provides binding sites for calcium ions.
(C) Its formation requires Vitamin K as a cofactor.
(D) It is derived by post-translational modification of glutamate residues.

2019

28. The peptide bond is best described chemically as a:
(A) Ester linkage
(B) Glycosidic linkage
(C) Substituted amide linkage
(D) Phosphodiester bond

2010

29. Which characteristic makes the peptide bond rigidly planar?
(A) Hydrogen bonding between adjacent residues
(B) Partial double-bond character due to resonance
(C) The presence of a proline residue
(D) Steric hindrance from large side-chains

2012

30. Consider the following statements about peptide bond dihedral angles:

I. The phi (ϕ) angle is the rotation around the alpha-carbon and nitrogen bond.

II. The psi (ψ) angle is the rotation around the alpha-carbon and carbonyl carbon bond.

III. The omega (ω) angle is typically 180 degrees due to the trans configuration.

Which of the above statements are correct?

(A) I and II

(B) I and III

(C) II and III

(D) I, II and III

2023

31. The resonance stabilization of the peptide bond results in a permanent dipole moment. In an alpha-helix, how do these individual dipoles align?

(A) Complete cancellation of individual dipoles within the helix

(B) Alignment along the helix axis producing a macroscopic dipole

(C) Anti-parallel alignment of dipoles relative to the helix axis

(D) Radial orientation of dipoles pointing outward from the helix

2017

32. Which dihedral angle pair is most conformationally restricted due to steric clashing in a polypeptide chain?

(A) $\Phi = -60, \Psi = -45$

(B) $\Phi = -120, \Psi = 120$

(C) $\Phi = -57, \Psi = -47$

(D) $\Phi = 0, \Psi = 0$

2018

33. The primary structure of a protein refers specifically to:

(A) The linear sequence of amino acids linked by peptide bonds

(B) The spatial arrangement of alpha-helices and beta-sheets

(C) The interaction between multiple polypeptide subunits

(D) The pattern of disulfide bridge formation

2015

34. Which chemical reagent is used in Edman degradation for N-terminal sequencing?

(A) 1-Fluoro-2,4-dinitrobenzene (FDNB)

(B) Dansyl chloride

(C) Phenylisothiocyanate (PITC)

(D) Cyanogen bromide (CNBr)

2005

35. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.

Assertion (A): Sanger's reagent (FDNB) is utilized to determine the complete amino acid sequence of a long polypeptide in a single reaction.

Reason (R): FDNB labels the N-terminal amino acid without hydrolyzing the rest of the peptide bonds.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

2005

36. Which method relies on high fluorescence for the detection of the N-terminal amino acid?

(A) Edman degradation

(B) Sanger's method

(C) Hydrazine cleavage

(D) Dansyl chloride method

2008

37. To determine the C-terminal amino acid of a peptide, which of the following is most appropriately used?

(A) Aminopeptidase

(B) Carboxypeptidase

(C) Cyanogen bromide

(D) Trypsin

2019

38. In identifying correct statements about primary structure determination, which of the following is true regarding Cyanogen bromide (CNBr)?

(A) Selective cleavage at the amino side of all lysine residues

(B) Identification of the specific N-terminal amino acid residues

(C) Cleavage at the carboxyl side of methionine residues

(D) Sequential removal of amino acids from the C-terminal end

NODIA

2024

39. Which of the following secondary structures is characterized by a right-handed coiled conformation with 3.6 residues per turn?

(A) Parallel beta-pleated sheet

(B) Beta-turn

(C) Left-handed collagen helix
(D) Alpha-helix

2008

40. Match the secondary structure element in List I with its characteristic feature in List II.
List I: (Structure Element)
P. Alpha-helix
Q. Antiparallel beta-sheet
R. Parallel beta-sheet
S. Beta-turn
List II: (Feature)
1. Hydrogen bonds are linear and strong
2. Involves four amino acid residues, often containing Proline or Glycine
3. Hydrogen bonds are distorted and weaker
4. Hydrogen bonds are parallel to the main axis
(A) P-4, Q-1, R-3, S-2
(B) P-4, Q-3, R-1, S-2
(C) P-1, Q-4, R-3, S-2
(D) P-3, Q-1, R-2, S-4

2019

41. In an alpha-helix, the hydrogen bond forms between the carbonyl oxygen of residue n and the amide hydrogen of residue:
(A) $n+2$
(B) $n+4$
(C) $n+3$
(D) $n+5$

2007

42. A Ramachandran plot displays the allowed conformations of polypeptides based on:
(A) The primary sequence of amino acids
(B) The specific combinations of phi and psi dihedral angles
(C) The pKa values of side chains
(D) The number of disulfide bonds

2023

43. Which amino acid is often referred to as a "helix breaker" due to its rigid cyclic structure disrupting the alpha-helical conformation?
(A) Proline
(B) Glycine
(C) Alanine
(D) Leucine

2013

44. What defines a protein motif (supersecondary structure)?
(A) An independently stable, compactly folded region of a single polypeptide
(B) The entire three-dimensional fold of a functional enzyme
(C) A specific recurring pattern of secondary structure elements
(D) The interaction between two separate polypeptide chains

2018

45. Consider the following statements about protein tertiary structure:
I. Domains are structurally independent folding units.
II. Chaperones dictate the final native fold of a protein.
III. Hydrophobic interactions are the major driving force for folding.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2023

46. Which interaction is primarily responsible for holding two different domains of a tertiary structure together?
(A) Peptide bonds
(B) Glycosidic linkages
(C) Non-covalent interactions (e.g., hydrophobic, ionic)
(D) Phosphodiester bonds

2003

47. What is the role of molecular chaperones in protein folding?
(A) They alter the primary sequence to facilitate folding.
(B) They provide a protected environment that prevents protein aggregation during folding.
(C) They lower the activation energy of peptide bond formation.
(D) They permanently bind to the folded protein to maintain its structure.

2010

48. Identify the incorrect pair regarding bonds stabilizing tertiary structure.
(A) Disulfide bonds - Covalent interaction
(B) Hydrophobic interactions - Driven by the increase in entropy of water
(C) Ionic bonds (Salt bridges) - Electrostatic interaction between oppositely charged groups
(D) Hydrogen bonds - Interaction between non-polar side chains

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2017

49. The spontaneous folding of a globular protein in an aqueous environment is thermodynamically driven mostly by:
(A) An increase in the entropy of the surrounding water molecules
(B) An increase in enthalpy due to hydrogen bonding
(C) A decrease in entropy of the polypeptide chain
(D) The formation of specific disulfide bonds

2013

50. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Quaternary structure refers to the spatial arrangement of multiple polypeptide subunits in a protein.
Reason (R): All functional proteins possess a quaternary structure.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2007

51. In oligomeric proteins, the subunits are most commonly held together by:
(A) Multiple non-covalent interactions
(B) Covalent peptide bonds
(C) Glycosidic linkages
(D) Metallic bonds

2011

52. Which symmetry is most commonly observed in dimeric proteins with identical subunits?
(A) Asymmetry
(B) Spherical symmetry
(C) Icosahedral symmetry
(D) C_2 rotational symmetry

2021

53. The principle of "salting in" refers to the observation that:
(A) High salt concentrations precipitate proteins out of solution.
(B) Low to moderate salt concentrations increase the solubility of a protein.
(C) Adding salt denatures the protein irreversibly.
(D) Salt ions form covalent bonds with the protein backbone.

2013

54. When high concentrations of ammonium sulfate are added to a protein solution, the protein precipitates. This phenomenon is known as:
(A) Salting in
(B) Isoelectric focusing
(C) Salting out
(D) Dialysis

2006

55. Match the protein analytical method in List I with its principle in List II.
List I: (Analytical Method)
P. UV absorbance at 280 nm
Q. Biuret test
R. Ninhydrin reaction
S. Salting out
List II: (Principle)
1. Color reaction with free amino groups
2. Complexation of cupric ions with peptide bonds
3. Competition for water of hydration by high salt
4. Absorption by aromatic amino acids (Trp, Tyr)
(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-1, S-3
(C) P-4, Q-1, R-2, S-3
(D) P-1, Q-2, R-3, S-4

NODIA

2010

56. The Biuret test is specific for detecting:
(A) The presence of two or more peptide bonds
(B) Free alpha-amino acids
(C) Disulfide bonds
(D) Aromatic amino acid residues

2010

57. Which color is typically produced when amino acids (except proline) react with Ninhydrin?
(A) Yellow
(B) Ruhemann's Purple
(C) Red
(D) Green

2002

58. Protein denaturation involves the disruption of which of the following?
(A) Primary structure only
(B) Secondary, tertiary, and quaternary structures without breaking peptide bonds
(C) Only the quaternary structure
(D) Both peptide bonds and non-covalent interactions

2022

59. Which of the following acts as a chaotropic agent used to denature proteins?
(A) Urea
(B) Beta-mercaptoethanol
(C) Ammonium sulfate
(D) Sodium chloride

2024

60. Consider the following statements about Anfinsen's experiment on Ribonuclease A:
I. Urea was used to disrupt non-covalent bonds.
II. Beta-mercaptoethanol was used to reduce disulfide bonds.
III. The protein refolded into its native state upon simultaneous removal of urea and beta-mercaptoethanol.
IV. The experiment proved that chaperones are mandatory for in vitro folding.
Which of the above statements are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I, III and IV

2006

61. What does Anfinsen's thermodynamic dogma state regarding protein folding?
(A) Proteins require ATP to fold into their native state.
(B) Denaturation of a protein is always an irreversible process.
(C) Disulfide bonds dictate the primary sequence of a protein.
(D) The native structure of a protein is determined solely by its amino acid sequence.

2010

62. Which of the following best describes the structural transition during the thermal denaturation of a globular protein?
(A) Gradual loss of structure over a significantly wide temperature range
(B) Irreversible enzymatic cleavage of the primary peptide bond linkage
(C) Cooperative transition from folded to unfolded state at Tm
(D) Spontaneous formation of a highly ordered crystalline protein lattice

2006

63. Fibrous proteins are fundamentally different from globular proteins because they:
(A) Are highly soluble in water
(B) Consist of single secondary structural elements arranged in long strands or sheets
(C) Have irregular, non-repeating secondary structures
(D) Serve primarily as enzymes and transport molecules

2016

64. The repetitive amino acid sequence typically found in the collagen triple helix is best represented by:
(A) (Ala-Gly)n, forming stacked beta-sheets
(B) (Cys-Cys-X)n, heavily cross-linked by disulfide bonds
(C) Poly-glutamate segments
(D) (Gly-X-Y)n, where X is often Proline and Y is often Hydroxyproline

2017

65. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Vitamin C deficiency leads to scurvy, characterized by fragile capillaries and poor wound healing.
Reason (R): Ascorbic acid is a required cofactor for prolyl hydroxylase, an enzyme essential for stabilizing the collagen triple helix.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

66. Alpha-keratin derives its structural strength and rigidity primarily from:
(A) Extensive beta-pleated sheet networks
(B) Covalent cross-links between lysine and histidine
(C) Coiled-coil structures stabilized by numerous disulfide bonds
(D) A high proportion of randomly coiled domains

2007

67. Elastin is a fibrous protein known for its elasticity. Which specific covalent cross-link is uniquely characteristic of elastin?
(A) Desmosine cross-links
(B) Cystine disulfide bonds
(C) Aldol cross-links
(D) Isopeptide bonds

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2015

68. Which of the following statements correctly compares globular and fibrous proteins?
(A) Globular proteins serve structural roles, whereas fibrous proteins serve functional roles.
(B) Fibrous proteins are sensitive to minor pH changes, whereas globular proteins are highly stable.
(C) Both types are equally soluble in physiological aqueous solutions.
(D) Globular proteins possess complex tertiary structures, whereas fibrous proteins generally lack complex tertiary folding.

2013

69. Glycoproteins contain carbohydrate chains covalently attached to amino acid side chains. N-linked glycosylation typically occurs at which amino acid residue?
(A) Serine
(B) Asparagine
(C) Threonine
(D) Tyrosine

2025

70. Match the conjugated protein class in List I with its non-protein prosthetic group in List II.
List I: (Conjugated Protein)
P. Lipoprotein
Q. Glycoprotein
R. Nucleoprotein
S. Phosphoprotein
List II: (Prosthetic Group)
1. Nucleic acids
2. Phosphate groups
3. Carbohydrates
4. Lipids
(A) P-4, Q-3, R-1, S-2
(B) P-4, Q-1, R-3, S-2
(C) P-3, Q-4, R-2, S-1
(D) P-1, Q-2, R-3, S-4

2007

71. O-linked glycosylation in proteins predominantly involves the hydroxyl groups of which amino acids?
(A) Tyrosine and Phenylalanine
(B) Aspartate and Glutamate
(C) Asparagine and Glutamine
(D) Serine and Threonine

2002

72. Lipoproteins are complexes that transport lipids in the blood. They are classified based on their density. Which class has the highest protein-to-lipid ratio?
(A) HDL (High-Density Lipoprotein)
(B) Chylomicrons
(C) VLDL (Very Low-Density Lipoprotein)
(D) LDL (Low-Density Lipoprotein)

2018

73. Nucleoproteins are complexes of nucleic acids and proteins. A classic example of a structural nucleoprotein complex in eukaryotes is:
(A) The ribosome
(B) Chromatin (DNA and histones)
(C) The sliceosome
(D) Both (A) and (B)

2024

74. The basic monomeric structure of an immunoglobulin (Ig) molecule consists of:
(A) One heavy chain and one light chain
(B) Two identical heavy chains and two identical light chains
(C) Four identical heavy chains
(D) A single polypeptide chain with multiple domains

2014

75. Consider the following statements about immunoglobulin classes:
I. IgG is the most abundant immunoglobulin in serum.
II. IgA is primarily found in mucosal secretions.
III. IgM exists primarily as a pentamer in serum.
IV. IgE is heavily involved in primary immune responses to viral infections.
Which of the above statements are correct?
(A) I, II and III
(B) II and III
(C) III and IV
(D) Only IV

NODIA

2021

76. Which region of the immunoglobulin molecule is responsible for specific antigen binding?
(A) The constant region of the heavy chain (Fc)
(B) The hinge region
(C) The variable regions of both heavy and light chains (Fab)
(D) The joining (J) chain

2014

77. Which immunoglobulin class is capable of crossing the mammalian placenta to confer passive immunity to the fetus?
(A) IgA
(B) IgM

(C) IgE
(D) IgG

2016

78. What determines the specific class (isotype) of an immunoglobulin?
(A) The amino acid sequence of the light chain variable region
(B) The presence of a specific antigen
(C) The amino acid sequence of the heavy chain constant region
(D) The disulfide bond arrangement in the Fab region

2007

79. Myoglobin is a globular protein primarily found in muscle tissue. Its primary physiological function is to:
(A) Transport oxygen from the lungs to the tissues
(B) Store oxygen and facilitate its diffusion in muscle cells
(C) Transport carbon dioxide to the lungs
(D) Buffer blood pH

2016

80. Consider the following statements regarding myoglobin:
I. It contains a single polypeptide chain.
II. It binds oxygen with cooperative kinetics.
III. Its prosthetic group is a heme molecule.
IV. Its oxygen binding curve is sigmoidal.
V. It has a higher affinity for oxygen than hemoglobin does at low partial pressures.
Which of the above statement(s) is/are correct?
(A) I, III and V
(B) II, III and IV
(C) I, II and V
(D) III, IV and V

2008

81. The oxygen-binding curve of myoglobin is characteristically:
(A) Hyperbolic
(B) Sigmoidal
(C) Linear
(D) Exponential

2024

82. In myoglobin and hemoglobin, the central iron atom of the heme group is in which oxidation state to reversibly bind oxygen?
(A) Fe0
(B) Fe3+ (Ferric)
(C) Fe2+ (Ferrous)
(D) Fe4+ (Ferryl)

2006

83. Metmyoglobin is formed when the heme iron:
(A) Is oxidized to the Fe3+ state, rendering it unable to bind oxygen
(B) Binds carbon monoxide instead of oxygen
(C) Forms a complex with 2,3-bisphosphoglycerate
(D) Is completely removed from the porphyrin ring

2003

84. Hemoglobin consists of multiple subunits, allowing for cooperative oxygen binding. Normal adult human hemoglobin (HbA) is composed of:
(A) Four alpha chains
(B) Two alpha chains and two gamma chains
(C) Four beta chains
(D) Two alpha chains and two beta chains

2021

85. Arrange the following states of hemoglobin during oxygenation in the correct sequential transition:
I. Low affinity T (tense) state
II. Binding of the first oxygen molecule
III. Disruption of salt bridges
IV. High affinity R (relaxed) state
(A) I → II → III → IV
(B) I → III → II → IV
(C) II → I → III → IV
(D) IV → III → II → I

2019

86. The sigmoidal oxygen-binding curve of hemoglobin indicates:
(A) Competitive inhibition
(B) Non-cooperative binding
(C) Positive cooperativity in oxygen binding
(D) Irreversible oxygen binding

2004

87. The Bohr effect describes the physiological phenomenon where hemoglobin's oxygen binding affinity:
(A) Increases significantly as the local pH of the environment decreases
(B) Decreases as the environmental temperature undergoes a reduction
(C) Increases when the concentration of 2,3-BPG is markedly elevated
(D) Decreases with lower pH and higher carbon dioxide

2004

88. What is the role of 2,3-bisphosphoglycerate (2,3-BPG) in regulating hemoglobin function?
(A) Binds and stabilizes the T state, decreasing

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oxygen affinity
(B) Binds the primary oxygen-binding site to act as a competitive inhibitor
(C) Binds the R state directly to increase the overall affinity for oxygen
(D) Oxidizes the central heme iron from the ferrous to the ferric state

2011

89. Fetal hemoglobin (HbF) has a higher oxygen affinity than adult hemoglobin (HbA) primarily because:
(A) Possession of a fundamentally different type of heme prosthetic group
(B) Reduced binding of 2,3-BPG due to altered gamma chain residues
(C) Requirement for operation at a different physiological pH environment
(D) Possession of a monomeric structural organization similar to myoglobin

2022

90. Consider the following statements regarding the allosteric regulation of hemoglobin:
I. Protons act as negative allosteric effectors.
II. Carbon dioxide covalently binds to the amino termini of subunits, stabilizing the T state.
III. Oxygen acts as a homotropic positive effector.
IV. 2,3-BPG increases the affinity of hemoglobin for oxygen.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

2019

91. A nucleoside is structurally composed of:
(A) A nitrogenous base and a pentose sugar
(B) A pentose sugar and a phosphate group
(C) A nitrogenous base, a pentose sugar, and a phosphate group
(D) A nitrogenous base and a phosphate group

2010

92. Which of the following is a pyrimidine base found exclusively in RNA?
(A) Cytosine
(B) Thymine
(C) Uracil
(D) Adenine

2012

93. What type of bond directly links the nitrogenous base to the pentose sugar in a nucleoside?
(A) Phosphodiester bond
(B) Alpha-O-glycosidic bond
(C) Hydrogen bond
(D) Beta-N-glycosidic bond

NODIA

2003

94. The structural difference between ribose and deoxyribose sugars lies at which carbon position?
(A) C-1'
(B) C-3'
(C) C-2'
(D) C-5'

2011

95. Consider the following components of nucleic acids:
I. Purines have a double-ring structure.
II. Adenine and Guanine are purines.
III. Thymine contains a methyl group not present in Uracil.
IV. Nucleotides are the phosphorylated forms of nucleosides.
V. The phosphate group is typically attached to the 2'-carbon of the sugar.
Which of the above statement(s) is/are correct?
(A) I, II, III and IV
(B) I, II, IV and V
(C) II, III, IV and V
(D) I, III, IV and V

2025

96. Tautomerization of nitrogenous bases (e.g., keto-enol or amino-imino shifts) is biologically significant because it can lead to:
(A) Significant enhancement of ultraviolet light absorption properties
(B) Increased structural stability of the sugar-phosphate backbone
(C) Transition between the standard B-DNA and the alternative Z-DNA
(D) Non-standard base pairing and spontaneous mutations

2010

97. Nucleic acids exhibit a strong absorption maximum in the ultraviolet spectrum at approximately 260 nm. This property is primarily due to:
(A) Conjugated double-bond systems of purine and pyrimidine bases
(B) Repetitive nature of the negatively charged phosphodiester backbone
(C) Structural characteristics of the cyclic

(A) Sodium chloride (NaCl)
(B) Ammonium sulfate
(C) Potassium phosphate
(D) Cesium chloride (CsCl)

2001

120. Arrange the following nucleic acid samples in order of increasing buoyant density in a CsCl gradient:
I. Double-stranded DNA (A-T rich)
II. Double-stranded DNA (G-C rich)
III. Single-stranded RNA
(A) I, II, III
(B) II, I, III
(C) III, II, I
(D) I, III, II

2007

121. The Sanger dideoxy method of DNA sequencing relies on the use of dideoxynucleoside triphosphates (ddNTPs). What essential functional group do ddNTPs lack?
(A) The 2'-hydroxyl group
(B) The 3'-hydroxyl group
(C) The 5'-phosphate group
(D) The nitrogenous base

2006

122. In the Sanger sequencing reaction, incorporation of a ddNTP results in:
(A) An increase in replication speed
(B) Immediate chain termination
(C) Introduction of a point mutation
(D) Cleavage of the existing DNA strand

2007

123. The Maxam-Gilbert method of DNA sequencing differs from the Sanger method in that it relies on:
(A) Base-specific chemical cleavage of an end-labeled DNA molecule
(B) Enzymatic synthesis of complementary strands
(C) Real-time detection of pyrophosphate release
(D) Passing DNA molecules through a nanopore

2018

124. In the classical Maxam-Gilbert method, which chemical is typically used to specifically cleave DNA at purine (G and A) residues?
(A) Hydrazine
(B) Cyanogen bromide
(C) Dimethyl sulfate (DMS) followed by piperidine
(D) Formic acid

2018

125. Restriction endonucleases are bacterial enzymes that function primarily to:
(A) Synthesize new DNA strands using a template-directed mechanism
(B) Ligate DNA fragments together to form continuous polynucleotides
(C) Unwind the DNA double helix during the process of replication
(D) Cleavage of foreign DNA at specific recognition sites

2010

126. Type II restriction endonucleases are most widely used in recombinant DNA technology because they:
(A) Require ATP for cleavage
(B) Cleave DNA at random sites far from the recognition sequence
(C) Cleave DNA at predictable positions within or near their specific recognition sequence
(D) Only cleave single-stranded DNA

2023

127. The recognition sequences for most Type II restriction enzymes exhibit what type of symmetry?
(A) Translational symmetry
(B) Palindromic symmetry (two-fold rotational symmetry)
(C) Asymmetry
(D) Spherical symmetry

2024

128. Cleavage of DNA by the restriction enzyme EcoRI produces fragments with:
(A) Blunt ends
(B) 5'-overhanging sticky ends
(C) 3'-overhanging sticky ends
(D) None of the above

2022

129. What is a "restriction map"?
(A) Diagram showing relative positions of restriction sites
(B) Geographical map of locations where recombinant DNA research is limited
(C) Structural map charting the tertiary folding of a restriction enzyme
(D) Sequence of the host genome protected by specific methylation patterns

2006

130. If a circular plasmid DNA is cut with a restriction enzyme that has three recognition

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(B) The D loop
(C) The 5'-end
(D) The 3'-CCA terminus

2001

110. Consider the following statements about RNA types:
I. rRNA is the most abundant type of RNA in a typical cell.
II. Ribozymes are RNA molecules possessing catalytic enzyme-like activity.
III. mRNA contains numerous modified bases such as pseudouridine.
IV. tRNA contains an anticodon sequence complementary to an mRNA codon.
V. The tertiary structure of tRNA resembles an L-shape.
Which of the above statement(s) is/are correct?
(A) I, II, IV and V
(B) I, III, IV and V
(C) II, III, IV and V
(D) I, II, III and V

2009

111. Which of the following is a well-known example of a catalytic RNA (ribozyme)?
(A) DNA polymerase
(B) Peptidyl transferase center of the ribosome
(C) Hexokinase
(D) Aminoacyl-tRNA synthetase

2001

112. The hyperchromic effect refers to:
(A) Significant decrease in the viscosity of DNA solutions upon heating
(B) Shift of the absorbance maximum from 260 nm toward the 280 nm range
(C) Increase in the buoyant density of DNA in a cesium chloride gradient
(D) Increased UV absorbance at 260 nm upon DNA denaturation

2010

113. The melting temperature (Tm) of a DNA sample is strongly influenced by its base composition. Which DNA molecule would have the highest Tm?
(A) A molecule with 70% G-C content
(B) A molecule with 30% G-C content
(C) A molecule with 50% G-C content
(D) A molecule consisting entirely of A-T pairs

2024

114. How does increasing the ionic strength (e.g., adding NaCl) of a solution affect the melting temperature (Tm) of DNA?
(A) Decreases the Tm by actively destabilizing internal hydrogen bonds
(B) Exhibits no measurable effect on the melting temperature of the DNA
(C) Increases Tm by shielding phosphate backbone repulsion
(D) Induces the immediate precipitation of all single-stranded DNA forms

2010

115. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Cot curve analysis (renaturation kinetics) provides information about the complexity of a genome.
Reason (R): Highly repetitive DNA sequences renature much more slowly than single-copy sequences.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

116. In a Cot curve, a low Cot value required for half-renaturation ($Cot_{\frac{1}{2}}$) indicates that the DNA sequence is:
(A) Highly complex and unique
(B) Rich in A-T base pairs
(C) Entirely composed of single-stranded RNA
(D) Highly repetitive

2004

117. The Svedberg coefficient (S) is a measure of a particle's:
(A) Electrical charge
(B) Sedimentation velocity under centrifugation relative to the centrifugal field
(C) Exact molecular weight
(D) Optical density

2021

118. In isopycnic density gradient centrifugation, nucleic acids separate based strictly on their:
(A) Shape
(B) Size and length
(C) Buoyant density
(D) Electrical charge

2013

119. Which salt is most commonly used to generate the density gradient for the separation of DNA in isopycnic centrifugation?

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pentose sugar ring systems
(D) Specific hydrogen bonding patterns occurring between complementary bases

2001

98. At physiological pH, the phosphate groups in the backbone of DNA and RNA are:
(A) Fully protonated and uncharged
(B) Positively charged
(C) Negatively charged, making nucleic acids polyanions
(D) Highly reactive and unstable

2015

99. According to Watson-Crick base pairing rules for double-stranded DNA, how many hydrogen bonds form between Guanine and Cytosine?
(A) One
(B) Two
(C) Three
(D) Four

2004

100. Select the correct order of sequence of events during the thermal denaturation of DNA:
I. Unstacking of base pairs
II. Breakage of hydrogen bonds
III. Separation into single strands
IV. Increase in UV absorbance at 260 nm
(A) I → II → IV → III
(B) II → I → IV → III
(C) IV → II → I → III
(D) II → I → III → IV

2008

101. The standard Watson-Crick double helix model represents which structural form of DNA?
(A) A-DNA
(B) B-DNA
(C) Z-DNA
(D) C-DNA

2016

102. In B-form DNA, one complete turn of the double helix encompasses approximately how many base pairs?
(A) 8.5
(B) 11.0
(C) 10.5
(D) 12.0

2011

103. Which feature distinctly characterizes Z-DNA compared to B-DNA?
(A) It is a right-handed helix.
(B) It is predominantly formed by poly-A tracts.
(C) It has a wider diameter and compressed rise per base pair.
(D) It possesses a left-handed helical rotation.

2025

104. Under conditions of low hydration (e.g., in crystalline forms or DNA-RNA hybrids), DNA tends to adopt which conformation?
(A) A-DNA
(B) B-DNA
(C) Z-DNA
(D) H-DNA

2003

105. Arrange the following structural features from smallest to largest parameter in standard B-DNA:
I. Rise per base pair
II. Helix diameter
III. Pitch (one complete turn)
(A) I → II → III
(B) II → I → III
(C) I → III → II
(D) III → II → I

2022

106. The major and minor grooves of B-DNA are structurally important because they:
(A) Provide the sites for phosphodiester bond cleavage
(B) Offer specific sequence-dependent binding sites for regulatory proteins
(C) Prevent the binding of water molecules
(D) Are exactly equal in depth and width

2006

107. Which type of RNA carries the genetic information from DNA to the ribosome for protein synthesis?
(A) mRNA
(B) rRNA
(C) tRNA
(D) snRNA

2019

108. The cloverleaf secondary structure is a defining characteristic of:
(A) Messenger RNA
(B) Ribosomal RNA
(C) Transfer RNA
(D) Micro RNA

2002

109. In the tRNA molecule, the amino acid is covalently attached to which specific region?
(A) The anticodon loop

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sites on the plasmid, how many DNA fragments are generated?
(A) Two
(B) Three
(C) Four
(D) Six

2002

131. Which of the following best defines an isoelectric point (pI)?
(A) The pH at which a molecule has a net charge of zero
(B) The pH at which a molecule has a maximum net positive charge
(C) The salt concentration required to precipitate a protein
(D) The temperature at which a protein denatures

2023

132. What causes the Bohr effect in hemoglobin?
(A) The binding of 2,3-BPG to the R-state
(B) Cleavage of the heme prosthetic group
(C) The oxidation of iron to the ferric state
(D) Protonation of specific histidine residues stabilizing the T-state

2023

133. Identify the incorrect statement regarding protein secondary structure.
(A) The alpha-helix is stabilized by hydrogen bonds between residues n and $n+4$.
(B) Proline is frequently found in the middle of standard alpha-helices because it stabilizes the turn.
(C) Beta-sheets can be formed by parallel or antiparallel strands.
(D) Beta-turns often involve hydrogen bonding between the carbonyl oxygen of the first residue and the amide hydrogen of the fourth.

2004

134. Which of the following forces provides the most significant energetic contribution to the stabilization of the native folded state of a globular protein in water?
(A) Hydrogen bonds between backbone amides
(B) Ionic interactions on the protein surface
(C) The hydrophobic effect
(D) Disulfide bridges

2001

135. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.

Assertion (A): The two strands of the Watson-Crick DNA double helix run antiparallel to each other.
Reason (R): The phosphodiester linkages in one strand are oriented 5' to 3', while in the complementary strand they are oriented 3' to 5'.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

136. Which structural parameter is characteristic of A-DNA?
(A) An 11 base pair per turn right-handed helix with tilted base pairs
(B) 10.5 base pairs per turn
(C) A left-handed zig-zag backbone
(D) Complete absence of a major groove

2002

137. Which combination represents non-polar, aliphatic amino acids?
(A) Serine, Threonine, Tyrosine
(B) Leucine, Isoleucine, Valine
(C) Aspartate, Glutamate, Asparagine
(D) Lysine, Arginine, Histidine

2001

138. The Ramachandran plot is a graph of:
(A) Absorbance versus wavelength
(B) Psi (ψ) versus phi (ϕ) angles
(C) pH versus volume of titrant
(D) Sedimentation coefficient versus density

2009

139. To resolve a mixture of proteins based purely on their isoelectric points, which technique is most appropriate?
(A) Isoelectric focusing
(B) Gel filtration chromatography
(C) SDS-PAGE
(D) Salting out

2009

140. Match the DNA modifying enzyme in List I with its function in List II.
List I: (DNA Modifying Enzyme)
P. Restriction Endonuclease
Q. DNA Ligase
R. DNA Polymerase
S. Reverse Transcriptase
List II: (Function)
1. Synthesizes DNA from an RNA template

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correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

162. Which of the following accurately describes an amphoteric molecule?
(A) A molecule with both hydrophilic and hydrophobic regions
(B) A molecule that absorbs light at two different wavelengths
(C) A molecule that can act as both an acid and a base
(D) A molecule containing two different metal ions

2013

163. The Edman degradation method removes amino acids from a peptide:
(A) One at a time from the N-terminus
(B) One at a time from the C-terminus
(C) In blocks of three from the N-terminus
(D) By random internal cleavage

2009

164. What stabilizes the quaternary structure of proteins?
(A) Only covalent bonds between subunits
(B) Phosphodiester linkages
(C) Base stacking interactions
(D) Non-covalent interactions and occasionally interchain disulfide bonds

2001

165. Consider the following statements about protein folding:
I. Protein folding is a random search process through all possible conformations.
II. Secondary structures form rapidly, leading to intermediate states like the molten globule.
III. The final native state is generally the thermodynamically most stable conformation.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2011

166. A major difference between DNA and RNA is that:
(A) RNA contains the base thymine.
(B) RNA cannot form any secondary structures.
(C) DNA has a 2'-H, while RNA has a 2'-OH on the pentose ring.
(D) DNA is typically single-stranded in biological systems.

2008

167. Which of the following best describes the structural transition that occurs when oxygen binds to hemoglobin?
(A) The alpha-helices completely unravel.
(B) The heme group dissociates from the globin chain.
(C) The beta subunits separate from the alpha subunits.
(D) The iron atom moves into the plane of the porphyrin ring.

2018

168. In B-DNA, the distance between adjacent stacked base pairs is approximately:
(A) 3.4 Angstroms
(B) 10.5 Angstroms
(C) 34 Angstroms
(D) 20 Angstroms

2006

169. What is the role of the 5'-cap and 3'-poly(A) tail in eukaryotic mRNA?
(A) They are required for the self-splicing of introns.
(B) They protect the mRNA from degradation and facilitate translation initiation.
(C) They serve as binding sites for restriction endonucleases.
(D) They direct the mRNA to the nucleus.

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2012

170. Match the term in List I with its description in List II.
List I: (Term)
P. Hyperchromic shift
Q. Cot curve
R. Zwitterion
S. Motif
List II: (Description)
1. Represents DNA reassociation kinetics
2. A molecule carrying both positive and negative charges
3. Increased UV absorbance upon DNA melting
4. A recognizable folding pattern of secondary structures
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

each other.

Which of the above statements are correct?

(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2009

151. What is the effect of carbon monoxide (CO) poisoning on oxygen transport?

(A) CO binds the heme group with a significantly lower affinity than oxygen
(B) CO induces the cleavage of peptide bonds within the globin protein chain
(C) CO allosterically stabilizes the T-state independently of heme binding
(D) CO binds heme iron with 250 times greater affinity than oxygen

2010

152. Which amino acid pair consists entirely of basic amino acids?

(A) Arginine and Lysine
(B) Aspartate and Glutamate
(C) Serine and Threonine
(D) Methionine and Cysteine

2022

153. A mutation changes a leucine residue to an isoleucine in the hydrophobic core of a protein. What is the most likely outcome?

(A) Complete unfolding of the protein
(B) Minimal structural disruption due to the conservative nature of the substitution
(C) A dramatic shift in the protein's pI
(D) Formation of a new disulfide bond

2005

154. What constitutes the secondary structure of a tRNA molecule?

(A) The specific linear sequence of ribonucleotides
(B) The cloverleaf arrangement created by localized base-pairing
(C) The L-shaped three-dimensional folding
(D) Its association with the ribosome

2002

155. Which of the following analytical techniques measures the mass-to-charge ratio of biological macromolecules and is commonly used to accurately determine protein mass?

(A) Mass spectrometry (e.g., MALDI-TOF)
(B) X-ray crystallography
(C) Analytical ultracentrifugation
(D) Nuclear Magnetic Resonance (NMR)

2006

156. The melting temperature (Tm) is defined as the temperature at which:

(A) DNA strands completely separate into individual nucleotides
(B) DNA begins to boil and break phosphodiester bonds
(C) 50% of the double-stranded DNA has denatured into single strands
(D) The hyperchromic effect is minimal

2004

157. Which amino acid sequence is a typical recognition site for a Type II restriction endonuclease?

(A) 5'-AAAAAA-3'
(B) 5'-ATCGGC-3'
(C) 5'-GATTACA-3'
(D) 5'-ATCGAT-3'

2018

158. The phenomenon where the binding of one oxygen molecule to hemoglobin facilitates the binding of subsequent molecules is termed:

(A) Negative allostery
(B) Competitive inhibition
(C) Positive cooperativity
(D) The Bohr effect

2012

159. Which type of bond is responsible for the primary structure of nucleic acids?

(A) Hydrogen bond
(B) Phosphodiester bond
(C) Glycosidic bond
(D) Disulfide bond

2016

160. Which modified amino acid acts as a calcium-binding site in blood coagulation proteins?

(A) Hydroxyproline
(B) Phosphoserine
(C) Selenocysteine
(D) Gamma-carboxyglutamate

2005

161. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.

Assertion (A): Hemoglobin acts as a significant buffer in the blood.

Reason (R): Hemoglobin binds carbon dioxide and protons, which helps maintain blood pH during carbon dioxide transport.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the

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2. Cleaves internal phosphodiester bonds at specific sites
3. Joins two DNA molecules by forming a phosphodiester bond
4. Synthesizes DNA from a DNA template

(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

2005

141. The function of the D-loop in a tRNA molecule is primarily associated with:
(A) Binding to the mRNA codon
(B) Covalent attachment of the amino acid
(C) Binding to the small ribosomal subunit
(D) Recognition by the correct aminoacyl-tRNA synthetase

2014

142. If a protein is totally denatured by urea and beta-mercaptoethanol, it will:
(A) Lose its primary sequence
(B) Immediately precipitate out of solution permanently
(C) Become a random coil
(D) Retain its catalytic activity

2013

143. Which of the following base pairs requires the highest temperature to denature?
(A) Adenine-Thymine
(B) Guanine-Cytosine
(C) Adenine-Uracil
(D) They all require the same temperature

2018

144. Which statement correctly differentiates between nucleosides and nucleotides?
(A) Nucleosides contain a phosphate group while nucleotides lack one
(B) Nucleosides are exclusively found in RNA while nucleotides are in DNA
(C) Nucleotides are uncharged while nucleosides possess a negative charge
(D) Nucleotides contain a phosphate group while nucleosides lack one

2011

145. What is the major consequence of the planar nature of the peptide bond?
(A) It restricts the polypeptide backbone to only a limited number of stable conformations.
(B) It allows free 360-degree rotation around the C-N bond.
(C) It prevents the formation of secondary structures.
(D) It makes the peptide bond highly susceptible to spontaneous hydrolysis.

2022

146. Which of the following is true concerning the 3D structure of hemoglobin?
(A) It contains beta-pleated sheets as its primary structural motif.
(B) The alpha and beta subunits share identical primary sequences.
(C) The spatial arrangement of subunits changes upon oxygen binding.
(D) It lacks a quaternary structure.

2019

147. A protein domain is best described as:
(A) An evolutionarily conserved, independently folded segment of a polypeptide chain
(B) A prosthetic group required for enzyme function
(C) A short repeating sequence of amino acids
(D) The interface between two different subunits in an oligomer

2014

148. Which is a characteristic feature of Type III restriction endonucleases?
(A) They recognize symmetric sequences and cleave strictly within them.
(B) They require ATP and cleave the DNA at a considerable, variable distance from the recognition site.
(C) They only modify (methylate) DNA but never cleave it.
(D) They cleave DNA precisely 24–26 base pairs away from the recognition site.

2003

149. Why is the 260/280 nm absorbance ratio commonly measured for nucleic acid samples?
(A) To determine the precise length of the DNA molecules
(B) To assess the purity of the nucleic acid preparation relative to protein contamination
(C) To measure the exact Tm of the DNA
(D) To differentiate between A-DNA and B-DNA

2008

150. Consider the following statements about immunoglobulin structural domains:
I. The heavy chain has one variable domain and multiple constant domains.
II. The light chain has one variable domain and one constant domain.
III. Disulfide bonds link the heavy chains to

NODIA

2019

171. Which amino acid is structurally an imino acid rather than a true alpha-amino acid?
(A) Proline
(B) Histidine
(C) Tryptophan
(D) Arginine

2008

172. How do enzymes accelerate biochemical reactions?
(A) By altering the overall change in free energy (ΔG)
(B) By shifting the reaction equilibrium to the right
(C) By lowering the activation energy required for the transition state
(D) By increasing the temperature of the microenvironment

2024

173. Which of the following forces prevents the steric clashing of atoms within a folded protein?
(A) Hydrogen bonds
(B) Disulfide bonds
(C) Ionic bridges
(D) Van der Waals repulsive forces

2013

174. Which process does the Sanger sequencing method exploit to determine DNA sequence?
(A) Chemical degradation of specific bases
(B) Measurement of pH changes during synthesis
(C) Chain termination by dideoxynucleotides during DNA synthesis
(D) Mass spectrometry fragmentation of the DNA

2016

175. Consider the following statements about restriction mapping:
I. It involves digesting DNA with different restriction enzymes singly and in combination.
II. Fragment sizes are estimated using agarose gel electrophoresis.
III. It reveals the exact nucleotide sequence of the entire DNA molecule.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2019

176. Which condition strongly favors the T-state of hemoglobin, promoting oxygen release?
(A) High partial pressure of oxygen in the lungs
(B) High pH in the tissues
(C) Absence of 2,3-BPG
(D) High levels of carbon dioxide in actively metabolizing tissues

2005

177. The term 'salting in' at low salt concentration is primarily due to:
(A) Masking of the electrostatic charges on the protein, reducing aggregation
(B) Competition between salt ions and the protein for water
(C) Formation of irreversible salt bridges
(D) Denaturation of the protein core

2010

178. What determines the sedimentation rate of a macromolecule in analytical ultracentrifugation?
(A) Only the electrical charge of the particle
(B) Only the mass of the particle
(C) Mass, shape, and density of the particle, and density of the solvent
(D) The primary sequence of the macromolecule exclusively

2016

179. The tertiary structure of a tRNA is predominantly maintained by:
(A) Extensive hydrogen bonding and base stacking interactions
(B) Covalent cross-links between distant bases
(C) Disulfide bonds
(D) Interactions with chaperonins

2010

180. Consider the following statements regarding the isoelectric point (pI):
I. At the pI, the protein has minimal solubility.
II. At the pI, the protein migrates towards the positive electrode in an electric field.
III. Proteins can be precipitated by adjusting the pH of the solution to their pI.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2006

181. In an alpha-helix, the R-groups of the amino acids:
(A) Point inward towards the central axis

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(B) Point outward, perpendicular to the central axis
(C) Alternate between pointing inward and outward
(D) Are packed tightly within the central core

2009

182. Which of the following is true regarding beta-sheets?
(A) Stabilization by hydrogen bonds between residues near each other
(B) Possession of weaker hydrogen bonds in the antiparallel orientation
(C) Formation by segments distant in the primary sequence
(D) Maintenance of a highly flexible and non-structural conformation

2016

183. Identify the incorrect statement concerning immunoglobulins.
(A) IgA is primarily found as a dimer in mucosal secretions.
(B) The hinge region provides flexibility to the Fab arms.
(C) IgM is the first antibody produced during a primary immune response.
(D) The light chain alone dictates antigen specificity.

2015

184. Silk fibroin, a classic fibrous protein, is composed predominantly of which secondary structure?
(A) Antiparallel beta-pleated sheets
(B) Alpha-helices
(C) Collagen triple helices
(D) Coiled coils

2004

185. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Type II restriction endonucleases cleave DNA within or near their specific recognition sequence.
Reason (R): Type II enzymes possess both endonuclease and methylase activities within the same polypeptide.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

186. Ribosomal RNA (rRNA) constitutes approximately what percentage of total cellular RNA in a typical prokaryote?
(A) 5%
(B) 15%
(C) 50%
(D) 80%

2001

187. The amino acid sequence of a protein directly dictates its three-dimensional structure. This principle was established by which scientist using Ribonuclease A?
(A) Christian Anfinsen
(B) Linus Pauling
(C) Frederick Sanger
(D) James Watson

NODIA

2021

188. Which of the following bonds allows a protein chain to turn sharply back on itself?
(A) Disulfide bond
(B) Alpha-helix
(C) Beta-turn (reverse turn)
(D) Peptide bond

2009

189. Which base pair has the strongest base-stacking interactions in double-stranded DNA?
(A) Adenine-Thymine pairs
(B) Thymine-Adenine pairs
(C) Cytosine-Guanine pairs
(D) G-C pairs

2014

190. Consider the following structural components of a nucleotide:
I. Purine or pyrimidine base
II. Deoxyribose or ribose sugar
III. Phosphodiester linkage
IV. Triphosphate group
Which of the above represents the precursor molecule used as a building block for DNA synthesis in vivo?
(A) I and II
(B) II and III
(C) Only IV
(D) I, II and IV

2007

191. The primary driving force for the formation of the DNA double helix in an aqueous environment is:
(A) Hydrogen bonding between complementary bases

(B) Base stacking interactions driven by the hydrophobic effect
(C) Electrostatic attraction between the phosphate backbones
(D) Covalent bonding between the bases

2005

192. During the denaturation of DNA, which type of bond is broken?
(A) Phosphodiester bonds
(B) Glycosidic bonds
(C) Carbon-carbon bonds in the sugar
(D) Hydrogen bonds

2004

193. The concept of "sticky ends" in recombinant DNA refers to:
(A) Single-stranded overhangs produced by specific restriction enzymes that can form base pairs with complementary sequences
(B) Blunt ends that are difficult to ligate
(C) Proteins that bind strongly to DNA
(D) Ends of chromosomes protected by telomeres

2018

194. Which of the following is true about myoglobin's structure?
(A) It consists of numerous beta-sheets forming a barrel.
(B) It is a tetramer in its functional state.
(C) It is a highly compact, globular protein composed mostly of alpha-helices.
(D) It lacks a prosthetic group.

2021

195. Match the molecular interaction in List I with its role in List II.
List I: (Interaction)
P. Disulfide bonds
Q. Hydrophobic interactions
R. Hydrogen bonds
S. Peptide bonds
List II: (Role)
1. Maintain the primary sequence
2. Drive core packing in tertiary structure
3. Covalently link distant parts of a polypeptide
4. Stabilize alpha-helices and beta-sheets
(A) P-3, Q-2, R-4, S-1
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-4, Q-2, R-3, S-1

2014

196. The Bohr effect shifts the oxygen dissociation curve of hemoglobin to the:
(A) Left, indicating increased affinity
(B) Upward, indicating higher maximum saturation
(C) Left, indicating decreased cooperativity
(D) Right, indicating decreased affinity

2019

197. Which of the following molecules allosterically reduces hemoglobin's affinity for oxygen, facilitating oxygen unloading in tissues?
(A) Carbon monoxide
(B) 2,3-Bisphosphoglycerate (2,3-BPG)
(C) Nitric oxide
(D) Bicarbonate ion

NODIA

2014

198. For the amino acid Lysine ($pK_1 = 2.18$, $pK_2 = 8.95$, $pK_R = 10.53$), what is the calculated isoelectric point (pI)?
(A) 5.57
(B) 6.42
(C) 9.74
(D) 10.53

2006

199. What dictates the migration pattern of nucleic acids in an analytical ultracentrifuge?
(A) Only their sequence
(B) The color of the dye added
(C) The GC content exclusively
(D) Their sedimentation coefficient, which depends on mass, size, and shape

2021

200. Consider the following features of B-DNA:
I. The helix is right-handed.
II. The bases are exposed on the surface.
III. The major groove is wide and deep.
IV. It is the dominant form in highly dehydrated environments.
Which of the above statements are correct?
(A) I and III
(B) II and IV
(C) I, III and IV
(D) I, II and III

2014

201. Which nitrogenous base undergoes spontaneous deamination to form Uracil?
(A) Adenine
(B) Cytosine
(C) Guanine
(D) Thymine

2004

202. The most prevalent conformation of naturally occurring dsDNA under physiological conditions is:
(A) A-form
(B) B-form
(C) Z-form
(D) Triple helix

2004

203. DNA polymerases require a template and a primer to synthesize a new DNA strand. In which direction is the new strand always synthesized?
(A) 3' to 5'
(B) 5' to 3'
(C) Both directions simultaneously
(D) It depends on the organism

2025

204. Which class of enzymes catalyzes the sequential removal of nucleotides from the ends of a DNA molecule?
(A) Endonucleases
(B) Ligases
(C) Exonucleases
(D) Polymerases

2022

205. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The Maxam-Gilbert sequencing method is now less commonly used than the Sanger method for routine sequencing.
Reason (R): Maxam-Gilbert sequencing requires toxic chemicals and complex procedural steps compared to the scalable, enzymatic Sanger method.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

206. Which structural component allows immunoglobulins to bind two antigens simultaneously?
(A) The Fc region
(B) The J chain
(C) The presence of two identical Fab regions
(D) The carbohydrate moiety

2019

207. Which analytical technique can determine the exact amino acid sequence of a short peptide from the N-terminus?
(A) X-ray crystallography
(B) Edman degradation
(C) Biuret test
(D) Ninhydrin reaction

2003

208. What is the fundamental principle behind identifying the C-terminal amino acid using carboxypeptidase?
(A) It permanently modifies the C-terminal amino acid, making it fluorescent.
(B) It forms a covalent bond with the C-terminus, causing precipitation.
(C) It sequences the entire protein starting from the C-terminus.
(D) It enzymatically hydrolyzes the peptide bond of the C-terminal amino acid, releasing it for identification.

2016

209. The specific activity of an enzyme refers to:
(A) The enzyme activity per milligram of total protein
(B) The total number of enzyme units in the sample
(C) The maximum velocity (Vmax) of the enzyme
(D) The turnover number (kcat)

2025

210. Match the amino acid in List I with its distinguishing structural feature in List II.
List I: (Amino Acid)
P. Tryptophan
Q. Cysteine
R. Proline
S. Histidine
List II: (Structural Feature)
1. Contains an imidazole ring
2. Contains an indole ring
3. Contains a sulfhydryl group
4. Cyclic imino acid structure
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-3, S-2

2016

211. Which form of RNA contains an anticodon?
(A) tRNA
(B) mRNA
(C) rRNA

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(D) snRNA

2024

212. What distinguishes a modified amino acid like selenocysteine from standard post-translationally modified amino acids?
(A) It is added to the protein sequence after translation is complete.
(B) It is only found in eukaryotic proteins.
(C) It does not form peptide bonds.
(D) It is incorporated into the polypeptide chain during translation via a specific tRNA.

2016

213. A protein with a high proportion of hydrophobic amino acids is most likely found:
(A) Free-floating in the cytoplasm
(B) Embedded within a lipid bilayer membrane
(C) In the blood plasma
(D) In the extracellular matrix

2008

214. Which amino acid provides the structural cross-links in keratin to make hair and nails rigid?
(A) Serine
(B) Glycine
(C) Cysteine
(D) Methionine

2024

215. Consider the following statements about collagen:
I. It is an extracellular matrix protein.
II. Its triple helix is stabilized by intermolecular hydrogen bonds.
III. Hydroxyproline is crucial for the thermal stability of the helix.
IV. Every third residue must be a bulky amino acid like tryptophan.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) II, III and IV
(C) I, III and IV
(D) I, II and IV

2004

216. The sigmoidal binding curve of hemoglobin reflects:
(A) Transition between high-affinity and low-affinity states
(B) A simple equilibrium binding process with a single binding site
(C) Covalent modification of the hemoglobin subunits
(D) Irreversible binding of oxygen

2004

217. When comparing the Ramachandran plots of different proteins, which amino acid consistently populates the widest range of phi and psi angles?
(A) Proline
(B) Glycine
(C) Tryptophan
(D) Isoleucine

2019

218. Protein denaturation by heat primarily involves the disruption of which of the following?
(A) Covalent peptide bonds
(B) Disulfide bridges
(C) Non-covalent interactions like hydrogen bonds and hydrophobic effects
(D) The primary sequence of amino acids

2003

219. Which interaction primarily drives the assembly of a multisubunit protein complex (quaternary structure)?
(A) Hydrophobic interactions between nonpolar patches on subunit surfaces
(B) Peptide bond formation
(C) Covalent cross-linking by enzymes
(D) Ester bond formation

2025

220. Consider the following statements regarding the physical properties of proteins:
I. Proteins exhibit minimum solubility at their isoelectric point.
II. High concentrations of salt generally increase protein solubility.
III. UV absorption at 280 nm is proportional to the content of aromatic amino acids.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

NODIA

2017

221. The Dansyl chloride method for N-terminal identification is advantageous because:
(A) It sequences the entire protein.
(B) It cleaves at methionine residues.
(C) It works specifically on basic amino acids.
(D) The resulting derivatives are highly fluorescent, allowing detection at low concentrations.

2006

222. What causes the hyperchromic shift when DNA is heated?

(B) Molecular weight
(C) Net charge
(D) Isoelectric point

2013

265. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.

Assertion (A): Dideoxynucleotides (ddNTPs) terminate DNA synthesis in the Sanger sequencing method.

Reason (R): ddNTPs lack the 3'-hydroxyl group necessary for the formation of the next phosphodiester bond.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2007

266. Which type of chromatography separates proteins based on their specific binding affinity to a ligand?
(A) Gel filtration chromatography
(B) Affinity chromatography
(C) Ion-exchange chromatography
(D) Hydrophobic interaction chromatography

2023

267. What is the role of sodium dodecyl sulfate (SDS) in SDS-PAGE?
(A) It denatures proteins and confers a uniform negative charge-to-mass ratio.
(B) It permanently cross-links the protein subunits.
(C) It stains the proteins for visualization.
(D) It preserves the native tertiary structure during electrophoresis.

2015

268. Which amino acid does NOT absorb ultraviolet light significantly at 280 nm?
(A) Tryptophan
(B) Tyrosine
(C) Glycine
(D) Phenylalanine

2002

269. The specific sequence of DNA that restriction endonucleases recognize is often:
(A) Highly repetitive and methylated
(B) Located only in telomeric regions
(C) Transcribed into rRNA
(D) A short palindromic sequence

2009

270. Match the protein purification technique in List I with its basis of separation in List II.

List I: (Purification Technique)
P. Ion-exchange chromatography
Q. Gel filtration chromatography
R. Affinity chromatography
S. Salting out

List II: (Basis of Separation)
1. Molecular size and shape
2. Reversible specific interaction with a ligand
3. Net surface charge
4. Differential solubility at high ionic strength

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-1, R-3, S-4

2014

271. An isoelectric focusing gel has a pH gradient from 3 to 10. A protein with a pI of 6.5 is loaded onto the basic end (pH 10) and subjected to an electric field. The protein will migrate:
(A) Toward the basic end until it runs off the gel
(B) Toward the acidic end until it reaches pH 6.5 and then stop
(D) It will not migrate because it becomes immediately denatured

2017

272. In an alpha-helix, hydrogen bonds are formed parallel to the helix axis. How many amino acid residues make up one complete turn of the alpha-helix?
(A) 2.0
(B) 3.6
(C) 5.4
(D) 10.5

2006

273. The characteristic repetitive structure of collagen consists of three polypeptide chains wrapped in a:
(A) Left-handed triple helix
(B) Right-handed triple helix
(C) Beta-barrel
(D) Series of alternating parallel and antiparallel beta-sheets

2012

274. Lipoproteins are critical for the transport of lipids in blood. Which structural component of lipoproteins makes them soluble in the aqueous blood plasma?
(A) The internal triglyceride core
(B) The hydrophobic cholesterol ester core

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(D) Arginine

2023

233. The isoelectric point (pI) of an acidic amino acid like aspartate is calculated by averaging the pKa values of:
(A) The alpha-carboxyl group and the alpha-amino group
(B) The alpha-carboxyl group and the side-chain carboxyl group
(C) The alpha-amino group and the side-chain carboxyl group
(D) It cannot be calculated simply by averaging.

2012

234. In analytical ultracentrifugation, the buoyant density of DNA depends primarily on its:
(A) Length
(B) G-C content
(C) Source organism
(D) Concentration

2023

235. Consider the following statements about RNA structure:
I. RNA can form complex tertiary structures.
II. Base-pairing in RNA often includes non-Watson-Crick pairs like G-U.
III. RNA is inherently less stable than DNA due to the 2'-hydroxyl group.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2018

236. Which of the following molecules serves as a secondary messenger in cellular signaling pathways?
(A) ADP
(B) cAMP
(C) Adenosine
(D) UTP

2021

237. The two complementary strands of the DNA double helix are held together primarily by:
(A) Phosphodiester bonds between opposite backbones
(B) Covalent bonds between bases
(C) Ionic bonds between the sugars
(D) Hydrogen bonds between specific base pairs

2014

238. In the Watson-Crick model of DNA, how many base pairs make up one full turn of the B-form helix?
(A) 9
(B) 10.5
(C) 12
(D) 3.4

2011

239. Which restriction endonuclease cleavage pattern generates "blunt ends"?
(A) Asymmetric cleavage within the recognition sequence
(B) Symmetric cleavage exactly in the center of the recognition sequence
(C) Cleavage outside the recognition sequence
(D) Cleavage that removes a single nucleotide

NODIA

2022

240. Arrange the following steps in recombinant DNA cloning in the correct sequential order:
I. Ligation of the DNA fragment into the vector
II. Transformation into host cells
III. Digestion of vector and insert with a restriction enzyme
IV. Selection of recombinant clones
(A) III → I → II → IV
(B) I → III → II → IV
(C) III → II → I → IV
(D) I → II → III → IV

2021

241. What is the primary function of chaperone proteins?
(A) To facilitate correct protein folding and prevent aggregation
(B) To degrade misfolded proteins
(C) To synthesize polypeptide chains
(D) To transport proteins across membranes

2004

242. Which chemical reagent specifically cleaves polypeptide chains on the carboxyl side of methionine residues?
(A) Trypsin
(B) Chymotrypsin
(C) Cyanogen bromide (CNBr)
(D) Pepsin

2005

243. At high altitudes, the human body adapts by increasing the concentration of 2,3-BPG in erythrocytes. What is the physiological effect of this change?

(A) Increases hemoglobin's affinity for oxygen to pick up more in the lungs
(B) Decreases hemoglobin's affinity for oxygen to facilitate unloading in tissues
(C) Stabilizes the R-state of hemoglobin
(D) Prevents the Bohr effect from occurring

2014

244. Myoglobin differs from hemoglobin structurally in that myoglobin:
(A) Lacks a heme prosthetic group
(B) Contains only beta-sheets
(C) Uses copper instead of iron to bind oxygen
(D) Is a single polypeptide chain (monomer)

2018

245. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): The melting temperature (Tm) of DNA increases as the GC content increases.
Reason (R): G-C base pairs are held together by three hydrogen bonds, which provide greater thermal stability than the two hydrogen bonds in A-T pairs.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

246. Which amino acid is most likely to be found on the exterior surface of a globular protein in an aqueous solution?
(A) Leucine
(B) Isoleucine
(C) Glutamine
(D) Valine

2010

247. The alpha-helix secondary structure is disrupted by:
(A) Adjacent oppositely charged amino acids
(B) Small hydrophobic amino acids like alanine
(C) Hydrogen bonding between backbone atoms
(D) The presence of proline or consecutive bulky amino acids

2011

248. The primary difference between normal adult hemoglobin (HbA) and fetal hemoglobin (HbF) is:
(A) HbF lacks beta chains, having gamma chains instead.
(B) HbF has a lower affinity for oxygen.
(C) HbF is a monomer.
(D) HbF does not bind 2,3-BPG at all.

2008

249. Which statement is correct regarding restriction mapping?
(A) It relies on measuring the rate of DNA replication.
(B) It involves determining the relative positions of restriction sites by analyzing fragment sizes.
(C) It maps only the coding regions of a gene.
(D) It utilizes DNA polymerase to synthesize maps.

2016

250. Match the immunoglobulin class in List I with its distinctive functional characteristic in List II.
List I: (Immunoglobulin Class)
P. IgG
Q. IgA
R. IgM
S. IgE
List II: (Functional Characteristic)
1. Major antibody of secondary immune response; crosses placenta
2. Main antibody in external secretions (tears, saliva)
3. Pentameric structure; efficient at agglutination
4. Mediates allergic reactions and defense against parasites
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-1, Q-3, R-2, S-4
(D) P-3, Q-2, R-1, S-4

2009

251. The Z-form of DNA is stabilized by:
(A) High salt concentrations and alternating purine-pyrimidine sequences
(B) Low salt concentrations and poly-A tracts
(C) Total dehydration of the sample
(D) High temperatures above the Tm

2021

252. Ribozymes are best defined as:
(A) Enzymes that degrade RNA
(B) Proteins that bind to ribosomes
(C) RNA molecules that possess catalytic activity
(D) Carbohydrates found in the ribosome

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2025

253. Which structural feature accounts for the strong UV absorption peak of proteins near 280 nm?
(A) Peptide bonds
(B) Disulfide bonds
(C) Free alpha-amino groups
(D) Aromatic amino acid residues (Tryptophan, Tyrosine)

2014

254. The process of renaturation of a denatured protein is usually:
(A) Impossible under any conditions
(B) Dependent solely on the presence of chaperones
(C) Spontaneous if the primary sequence is intact and appropriate conditions are restored
(D) Driven by the formation of incorrect disulfide bonds

2017

255. Consider the following statements about collagen:
I. It is a globular protein.
II. It possesses a triple-helical structure.
III. Glycine occurs at every third position in the primary sequence.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2019

256. What type of covalent bond connects individual nucleotides in a single strand of DNA?
(A) Hydrogen bond
(B) Beta-N-glycosidic bond
(C) Disulfide bond
(D) 3',5'-Phosphodiester bond

2006

257. Which term describes the temperature at which half of the helical structure of DNA is lost?
(A) Melting temperature (Tm)
(B) Isoelectric point (pI)
(C) Annealing temperature
(D) Boiling point

2022

258. What makes Type II restriction enzymes particularly useful for gene cloning?
(A) They cleave outside their recognition sequence.
(B) They exhibit exonuclease activity to chew back DNA ends.
(C) They cleave at precise locations within a specific recognition sequence.
(D) They randomly fragment large genomic DNA.

2016

259. A restriction map of a linear DNA molecule shows two restriction sites for the enzyme BamHI. Digestion with BamHI will yield how many fragments?
(A) One
(B) Two
(C) Three
(D) Four

2023

260. Arrange the following steps in the Maxam-Gilbert sequencing method in the correct sequential order:
I. Chemical cleavage of the DNA chain
II. End-labeling of the DNA fragment
III. Base-specific chemical modification
IV. High-resolution polyacrylamide gel electrophoresis
(A) II → III → I → IV
(B) III → I → II → IV
(C) II → I → III → IV
(D) I → III → II → IV

2016

261. The structural conformation of the A-form of DNA compared to B-form is:
(A) Longer and narrower
(B) Shorter and wider with tilted base pairs
(C) A left-handed helix
(D) Completely devoid of base pairing

2012

262. Which chemical reagent is used to reduce disulfide bonds in proteins?
(A) Urea
(B) Guanidinium chloride
(C) Beta-mercaptoethanol
(D) Sodium dodecyl sulfate

2010

263. The primary structure of a protein is held together by:
(A) Hydrogen bonds
(B) Disulfide bonds
(C) Hydrophobic interactions
(D) Peptide bonds

NODIA

2022

264. In reverse-phase HPLC, proteins are separated primarily based on their:
(A) Hydrophobicity

(A) The phosphodiester backbone breaks.
(B) The bases undergo chemical modification.
(C) Base stacking interactions are disrupted, increasing the molar extinction coefficient.
(D) Water molecules are expelled from the major groove.

2009

223. What information does a typical Cot curve provide about a DNA sample?
(A) The exact nucleotide sequence
(B) The proportion of unique, moderately repetitive, and highly repetitive sequences
(C) The location of restriction enzyme sites
(D) The molecular weight of the DNA

2023

224. Which type of bond is responsible for the primary structure of nucleic acids?
(A) Hydrogen bond
(B) Phosphodiester bond
(C) Glycosidic bond
(D) Disulfide bond

2015

225. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.
Assertion (A): Sickle cell anemia is caused by a single amino acid substitution in the beta chain of hemoglobin.
Reason (R): The substitution of glutamate with valine creates a hydrophobic patch that leads to hemoglobin aggregation under low oxygen conditions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

226. What structural feature of the peptide bond is depicted by a Ramachandran plot?
(A) The cis/trans isomerization ratio
(B) The length of the C-N bond
(C) The allowed rotational angles around the N-Cα and Cα-C bonds
(D) The distance between adjacent alpha-carbons

2019

227. A protein motif characterized by a helix-loop-helix structure often functions to:
(A) Bind calcium ions or specific DNA sequences
(B) Penetrate lipid bilayers
(C) Form extracellular structural fibers
(D) Absorb light

2011

228. Which of the following is true about protein domains?
(A) They are strictly defined by their primary sequence alone.
(B) Domains are only found in multimeric proteins.
(C) They consist exclusively of alpha-helices.
(D) A single polypeptide chain can contain multiple independently folding domains.

2018

229. The process of protein denaturation:
(A) Involves the cleavage of peptide bonds
(B) Usually results in the loss of biological activity
(C) Is always irreversible
(D) Increases the protein's solubility in water

2024

230. Match the analytical method in List I with the property it measures in List II.
List I: (Analytical Method)
P. SDS-PAGE
Q. Isoelectric focusing
R. Gel filtration chromatography
S. Analytical ultracentrifugation
List II: (Property Measured)
1. Sedimentation coefficient
2. Molecular weight (mass) of denatured subunits
3. Native molecular size (Stokes radius)
4. Isoelectric point (pI)
(A) P-2, Q-4, R-3, S-1
(B) P-3, Q-4, R-2, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-3, S-2

2016

231. Which non-covalent interaction is most susceptible to disruption by changes in pH?
(A) Hydrophobic interactions
(B) Van der Waals forces
(C) Disulfide bonds
(D) Salt bridges (ionic interactions)

2006

232. Which of the following amino acids contains a side chain pKa closest to physiological pH (7.4)?
(A) Histidine
(B) Glutamate
(C) Lysine

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(C) The surface layer of amphipathic phospholipids and apolipoproteins
(D) Carbohydrate branches covalently linked to the core lipids

2025

275. Consider the following properties of hemoglobin:
I. It exhibits sigmoidal oxygen binding kinetics.
II. Its affinity for oxygen decreases as pH drops.
III. It is a tetrameric protein.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2013

276. Which base is not found in typical cellular DNA?
(A) Adenine
(B) Cytosine
(C) Thymine
(D) Uracil

2018

277. The melting point (Tm) of a DNA sample is experimentally defined as the temperature at which:
(A) The sample begins to visibly precipitate
(B) The hyperchromic shift is 50% complete
(C) The DNA absorbs maximally at 280 nm
(D) The phosphodiester bonds begin to break

2011

278. Which of the following restriction enzymes produces blunt ends?
(A) EcoRI
(B) BamHI
(C) SmaI
(D) HindIII

2017

279. The biological significance of the major groove in B-DNA is that it:
(A) Is the site of DNA supercoiling
(B) Houses the phosphodiester bonds
(C) Prevents structural damage from UV radiation
(D) Provides a wide surface for sequence-specific recognition by DNA-binding proteins

2008

280. Match the nucleic acid component in List I with its description in List II.
List I: (Nucleic Acid Component)
P. Purine
Q. Pyrimidine
R. Nucleoside
S. Nucleotide
List II: (Description)
1. Base + sugar + phosphate
2. Single-ring nitrogenous base
3. Double-ring nitrogenous base
4. Base + sugar
(A) P-3, Q-2, R-4, S-1
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-2, R-1, S-4
(D) P-1, Q-4, R-2, S-3

2013

281. The term "cooperativity" in hemoglobin oxygen binding refers to the fact that:
(A) Hemoglobin must cooperate with myoglobin to deliver oxygen.
(B) The binding of one oxygen molecule increases the affinity of the remaining vacant sites for oxygen.
(C) Alpha and beta chains have identical oxygen affinities.
(D) Oxygen binding requires the simultaneous binding of carbon dioxide.

2001

282. The Bohr effect physiologically facilitates the delivery of oxygen to rapidly metabolizing tissues because these tissues:
(A) Produce less carbon dioxide
(B) Produce carbon dioxide and lactic acid, lowering the local pH and promoting oxygen release
(C) Have a higher local pH
(D) Completely lack 2,3-BPG

2022

283. What defines an essential amino acid?
(A) It cannot be synthesized by the organism at a rate commensurate with its demand, and must be obtained from the diet.
(B) It contains sulfur.
(C) It is absolutely required for the synthesis of exclusively brain proteins.
(D) It is an amino acid that functions as an enzyme.

2016

284. Which non-standard amino acid is commonly found in the protein elastin, contributing to its highly cross-linked structure?
(A) Hydroxyproline
(B) Selenocysteine
(C) Desmosine
(D) Gamma-carboxyglutamate

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remains zero, characterizing the zwitterionic species.

19. (A) Cation migrating towards the cathode
The isoelectric point is the pH where an amino acid has no net charge. When the surrounding environment becomes more acidic than this point, the excess protons lead to the protonation of the carboxylate group while the amino group remains protonated. This shift results in a net positive charge on the molecule, causing it to migrate toward the negative electrode.

20. (C) A is true but R is false.
Titration of a simple amino acid reveals buffering regions associated with each ionizable group. For glycine, these regions correspond to the α -carboxyl and α-amino groups. Since glycine has a hydrogen atom as its side chain, it lacks any additional ionizable groups that would create further buffering zones. The assertion regarding two regions is correct, but the reason is false.

21. (B) The average of pK_1 and pK_2
The isoelectric point represents the precise pH at which the population of amino acid molecules carries no net electrical charge. For an amino acid with a non-ionizable side chain, this point is found by calculating the arithmetic mean of the two dissociation constants. Specifically, averaging the pK_a of the carboxyl group and the pK_a of the amino group yields the pI.

22. (C) Net negative charge (-1)
Glutamate is an acidic amino acid with three ionizable groups. At physiological pH, both the α-carboxyl group and the side-chain γ-carboxyl group are deprotonated and negatively charged, while the α-amino group is protonated and positively charged. The combination of two negative charges and one positive charge results in a net charge of negative one for the molecule in typical biological fluids.

23. (D) Post-translational hydroxylation requiring Vitamin C
Collagen stability relies on the presence of hydroxyproline, which is produced after the polypeptide chain has been synthesized on the ribosome. This reaction involves the enzymatic addition of a hydroxyl group to specific proline residues. The enzyme responsible for this post-translational modification, prolyl hydroxylase, requires molecular oxygen and Vitamin C as a necessary cofactor to maintain its catalytic iron in the correct state.

NODIA

24. (A) Co-translational incorporation via a recoded stop codon
While most amino acids are modified after translation, selenocysteine is incorporated directly during the synthesis of the polypeptide. This process involves a unique tRNA that recognizes the UGA stop codon when a specific secondary structure is present in the mRNA. This recoding mechanism allows for the specific placement of this selenium-containing residue, which is essential for the function of certain antioxidant enzymes.

25. (A) P-3, Q-2, R-1, S-4
Non-standard amino acids fulfill specialized biological functions. γ-carboxyglutamate is essential for the calcium-binding properties of clotting factors. Hydroxyproline provides structural integrity to the collagen triple helix. Pyrrolysine is utilized by specific methanogens in their metabolic pathways. Selenocysteine serves as a critical catalytic residue in glutathione peroxidase, demonstrating the functional diversity achieved through the modification or recoding of the standard genetic alphabet.

26. (B) Gamma-aminobutyric acid (GABA)
Certain amino acids and their derivatives function as signaling molecules rather than structural components of proteins. γ-aminobutyric acid is produced by the decarboxylation of glutamate and serves as the primary inhibitory neurotransmitter in the central nervous system. By binding to specific receptors, it modulates neuronal excitability, playing a fundamental role in brain function and the regulation of muscle tone throughout the body.

27. (A) It is heavily concentrated in the protein collagen.
γ-carboxyglutamate is formed through the post-translational modification of glutamate residues in a process that requires Vitamin K. This modified amino acid is characteristically found in proteins involved in blood coagulation, such as prothrombin, where it facilitates calcium binding. It is not a major component of collagen, which instead relies on hydroxyproline and hydroxylysine for its structural stability and cross-linking properties.

(B) The melting temperature (Tm)
(C) The sedimentation coefficient, which correlates with molecular weight and shape
(D) The absolute primary sequence of proteins

2015

295. Consider the following elements of recombinant DNA technology:
I. Type II Restriction Endonuclease
II. DNA Ligase
III. Plasmid Vector
IV. Competent Host Cell
V. Transformation Process
Which of the above are required for cloning a DNA fragment?
(A) I, II, III, IV and V
(B) I, II, III and IV
(C) II, III, IV and V
(D) I, III, IV and V

2021

296. In gel filtration chromatography, molecules are separated based on their size. Which molecules elute first from the column?
(A) The largest molecules, because they are excluded from the pores of the beads and pass rapidly through the column.
(B) The smallest molecules, because they enter the pores of the beads and are delayed.
(C) The most highly charged molecules.
(D) The most hydrophobic molecules.

2017

297. What is the primary function of the joining (J) chain in immunoglobulins?
(A) It connects the heavy chain to the light chain.
(B) It facilitates the polymerization of IgA into dimers and IgM into pentamers.
(C) It provides the specific antigen-binding site.
(D) It attaches the carbohydrate side chains to the constant region.

2016

298. Which of the following is true about non-standard amino acids?
(A) They are synthesized directly by ribosomes without post-translational modification.
(B) They are often produced by post-translational enzymatic modification of standard amino acids within a polypeptide.
(C) They are never found in functionally active proteins.
(D) They consist exclusively of D-enantiomers.

2004

299. Restriction enzymes that recognize the same DNA sequence but cleave it at different positions are known as:
(A) Isoschizomers
(B) Neoschizomers
(C) Restriction isomers
(D) Methylases

2007

300. The precise order of amino acids in a polypeptide chain is defined as its:
(A) Secondary structure
(B) Tertiary structure
(C) Primary structure
(D) Quaternary structure

****

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ANSWERS

1. (A) Exclusively L-configuration
L-amino acids are the building blocks of proteins in nature. The chiral center at the α -carbon determines the L or D orientation. During evolution, biological systems selected the L-form for ribosomal synthesis. Although D-amino acids exist in bacterial cell walls, the translational machinery in all domains of life exclusively incorporates the L-stereoisomers into polypeptide chains.

2. (C) Glycine
The central carbon atom in amino acids is typically bonded to four distinct groups, making it a stereocenter. However, glycine is the simplest amino acid and has a hydrogen atom as its side chain. Since there are two identical hydrogen atoms attached to its α-carbon, the molecule is achiral and does not exhibit optical activity or enantiomerism.

3. (A) Presence of an asymmetric α-carbon
Most standard amino acids possess a central α -carbon bonded to four unique chemical groups, which creates a center of asymmetry. This chiral arrangement allows the molecules to rotate plane-polarized light in different directions. Such asymmetry is the fundamental requirement for optical activity, enabling these biomolecules to exist as two distinct, non-superimposable mirror images known as enantiomers.

4. (D) All L-amino acids are dextrorotatory (+).
The classification of amino acids as L or D is based on their structural similarity to glyceraldehyde rather than the direction in which they rotate plane-polarized light. While all protein-derived amino acids share the L-configuration, they can be either dextrorotatory or levorotatory. Therefore, the L-designation does not imply a specific sign for the measured optical rotation in a polarimeter.

5. (A) Both A and R are true and R is the correct explanation of A.
Protein synthesis occurs on ribosomes, where specific enzymes like aminoacyl-tRNA synthetases ensure the high fidelity of translation. These enzymes are highly stereospecific, recognizing and attaching only L-amino acids to their corresponding tRNA molecules. This evolutionary preference ensures that proteins are constructed from a uniform set of stereoisomers, which is critical for the proper folding and function of polypeptides.

NODIA

(C) Non-ribosomal peptide synthesis
Standard ribosomal translation exclusively utilizes L-amino acids due to the stereospecificity of the translational machinery. In contrast, certain microorganisms utilize specialized multi-enzyme complexes to synthesize peptides independently of ribosomes. These non-ribosomal peptide synthetases can incorporate diverse building blocks, including D-amino acids and other non-proteinogenic residues, which are commonly found in specialized metabolites like antibiotics and toxins.

7. (D) Serine
Functional groups within amino acid side chains dictate their chemical properties at physiological pH. Serine possesses a hydroxyl group attached to its β-carbon, which introduces polarity through oxygen's electronegativity. Despite this polarity, the side chain remains uncharged under neutral conditions. This makes it distinct from hydrophobic aliphatic residues like leucine or electrically charged groups like those found in aspartate or lysine.

8. (A) Tryptophan
Aromatic amino acids contain conjugated ring systems that absorb light in the ultraviolet region. Among these, tryptophan possesses an indole ring which provides the most significant molar extinction coefficient at a wavelength of 280 nanometers. This property makes it the primary contributor to the UV absorbance of proteins, which is frequently exploited in laboratories for protein concentration measurements.

9. (B) Valine and Isoleucine
Globular proteins fold in aqueous environments to maximize stability by sequestering nonpolar side chains away from water. Valine and isoleucine contain branched, aliphatic hydrocarbon R-groups that lack polar or charged functional

groups. These hydrophobic properties drive them to cluster within the internal core of the protein, effectively reducing the solvent-exposed surface area and stabilizing the overall structure.

10. (A) P-3, Q-4, R-1, S-2
Amino acids are grouped by the chemical nature of their side chains. Arginine contains a guanidino group that is basic at neutral pH. Phenylalanine features a non-polar aromatic ring. Aspartate has a carboxyl group that is acidic and negatively charged. Threonine contains a polar hydroxyl group but carries no net charge, illustrating the diverse chemical landscape of protein building blocks.

11. (A) Methionine
The sulfur-containing amino acids in proteins include cysteine and methionine. While cysteine contains a reactive sulfhydryl group, methionine features a sulfur atom bonded to two different carbon atoms within its side chain. This specific chemical arrangement is known as a thioether linkage. This non-polar, hydrophobic residue plays a vital role in initiating protein translation and stabilizing protein structures.

12. (C) Side-chain pK_a near physiological pH
The imidazole side chain of histidine has a dissociation constant near neutrality, allowing it to exist in both protonated and deprotonated forms at physiological conditions. This unique property enables it to function effectively as a general acid or base in enzyme catalysis. By shuttling protons, histidine facilitates various biochemical transformations, making it a critical residue in many catalytic active sites.

13. (D) Amino acid synthesized normally but required during stress
Most amino acids are synthesized by the body in sufficient quantities for normal physiological maintenance. However, during periods of extreme physiological stress, rapid growth, or specific disease states, the demand for certain amino acids may exceed the endogenous biosynthetic capacity. Under these specific conditions, these normally non-essential amino acids must be obtained from dietary sources to support metabolic needs.

14. (C) Tryptophan
Humans lack the biosynthetic pathways to produce certain amino acids from simple metabolic precursors. Tryptophan is one such molecule that must be obtained through the diet. It serves as a vital precursor for the synthesis of the neurotransmitter serotonin and the vitamin niacin. Maintaining adequate levels of this essential residue is necessary for normal protein synthesis and overall metabolic health.

15. (B) I and III
Nutritional classification identifies amino acids based on metabolic fate and dietary requirements. Leucine and lysine are categorized as strictly ketogenic because their degradation produces only acetyl-CoA or acetoacetate. Additionally, arginine is considered semi-essential because children cannot synthesize it fast enough to support their rapid development, even though healthy adults can produce sufficient amounts to meet their routine physiological requirements.

16. (D) Endogenous synthesis from metabolic intermediates
Organisms have evolved metabolic pathways to synthesize a subset of amino acids using intermediates from the citric acid cycle or glycolysis. Because the body can produce these molecules endogenously, they are termed non-essential. These residues remain critical for protein synthesis, but their availability is not strictly dependent on dietary intake, allowing the cell to maintain homeostasis under varying nutritional conditions.

17. (A) Phenylalanine - Non-essential
Phenylalanine is a vital aromatic amino acid that humans cannot synthesize de novo. It must be provided in the diet to support protein construction and to serve as a precursor for the production of tyrosine. In contrast, molecules like proline are readily synthesized from glutamate and are thus non-essential. Misclassifying phenylalanine as non-essential ignores the metabolic requirement for its external supply.

18. (C) Net zero charge with localized positive and negative charges
At a specific pH range, amino acids exist in a dipolar form where the amino group is protonated and the carboxyl group is deprotonated. This state results in a molecule that contains both a positive and a negative charge on different functional groups. Although the molecule has localized charges, the overall net electrical charge

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37. (B) Carboxypeptidase
While chemical methods like Edman degradation sequence from the N-terminus, enzymatic approaches are often used for the other end. Carboxypeptidases are exopeptidases that specifically cleave the peptide bond of the amino acid located at the carboxyl terminus. By monitoring the order in which amino acids are released over time, researchers can determine the sequence at the C-terminal end of the polypeptide.

38. (C) Cleavage at the carboxyl side of methionine residues
To sequence large proteins, they must be broken into smaller, manageable fragments. Cyanogen bromide is a chemical reagent that achieves this by specifically targeting methionine residues. It cleaves the peptide bond on the carboxyl side of these residues, converting the methionine into a C-terminal homoserine lactone. This highly selective cleavage is an essential step in generating overlapping peptides for primary structure determination.

39. (D) Alpha-helix
The alpha-helix is a common secondary structure where the polypeptide backbone twists into a spiral. This conformation is typically right-handed and is stabilized by internal hydrogen bonds. Each turn of the helix spans approximately 3.6 amino acid residues, creating a compact and rigid cylinder. The side chains extend outward from the helical core, allowing them to interact with the surroundings.

40. (A) P-4, Q-1, R-3, S-2
Different secondary structures are defined by their hydrogen bonding patterns and geometry. The alpha-helix features hydrogen bonds parallel to the axis. Antiparallel beta-sheets are stabilized by linear, strong hydrogen bonds between strands. Parallel beta-sheets contain distorted, weaker bonds. Beta-turns are small elements typically involving four residues, where glycine and proline are frequently used to facilitate the sharp change in chain direction.

41. (B) $n+4$
The stability of the alpha-helix is provided by hydrogen bonds between the atoms of the polypeptide backbone. Specifically, the carbonyl oxygen of an amino acid residue forms a bond with the amide hydrogen of the residue located four positions further along the chain. This repeating n to $n+4$ bonding pattern maintains the tight helical turn and defines the structural regularity of the helix.

42. (B) The specific combinations of ϕ and ψ dihedral angles
The three-dimensional fold of a protein is constrained by the rotational freedom of the polypeptide backbone. A Ramachandran plot provides a visual representation of these constraints by plotting the ϕ and ψ dihedral angles. The plot reveals specific regions where combinations of these angles are permitted due to favorable interactions and other regions that are forbidden because of steric clashes between atoms.

43. (A) Proline
Proline is unique among the standard amino acids because its side chain is cyclized onto the backbone nitrogen. This rigid ring structure prevents the N-Cα bond from rotating freely and lacks the amide hydrogen necessary for standard helical hydrogen bonding. Consequently, the presence of proline introduces a kink in the polypeptide chain, making it unable to fit into a regular alpha-helix.

44. (C) A specific recurring pattern of secondary structure elements
Supersecondary structures, also known as motifs, represent recurring arrangements of secondary structure elements found in many different proteins. These patterns, such as the β-α-β unit or the Greek key, serve as intermediate levels of organization between simple helices or sheets and the fully folded tertiary structure. While motifs are recognizable folding patterns, they do not always fold independently into stable units.

45. (B) I and III
The tertiary structure describes the complete three-dimensional folding of a single polypeptide chain. Domains are independently stable parts of this structure that can often fold on their own. The primary driving force for this folding process is the hydrophobic effect, where nonpolar residues cluster together. While chaperones assist in folding by preventing aggregation, they do not dictate the final native conformation.

NODIA

28. (C) Substituted amide linkage
The linkage between amino acids in a protein is formed by a dehydration reaction between the alpha-carboxyl group of one residue and the alpha-amino group of the next. Chemically, this bond is a substituted amide. It forms the covalent backbone of the polypeptide chain, providing the structural continuity required to build complex three-dimensional protein architectures from linear sequences of amino acids.

29. (B) Partial double-bond character due to resonance
The peptide bond exhibits resonance where electrons are shared between the carbonyl oxygen, the carbon, and the amide nitrogen. This delocalization gives the C-N bond partial double-bond character, which prevents free rotation. Consequently, the atoms involved in the bond are held in a rigid, planar configuration. This planarity significantly constrains the possible conformations that a polypeptide chain can adopt during folding.

30. (D) I, II and III
The conformation of a polypeptide is described by rotations around three main bonds. The ϕ angle involves rotation around the nitrogen and α-carbon bond, while the ψ angle refers to the α -carbon and carbonyl carbon bond. The ω angle represents rotation around the peptide bond itself, which is generally fixed at 180 degrees in the more stable trans configuration due to resonance.

31. (B) Alignment along the helix axis producing a macroscopic dipole
The peptide bond possesses a permanent dipole due to the separation of charge between the carbonyl oxygen and the amide nitrogen. In an alpha-helix, all peptide bonds are oriented in the same direction, causing their individual dipoles to sum together. This alignment results in a significant macroscopic dipole for the entire helix, with a positive charge at the amino-terminal end.

32. (D) $\phi = 0$, $\psi = 0$
Polypeptide chains cannot adopt every possible combination of dihedral angles because certain orientations cause atoms to come too close together. When both ϕ and ψ are zero, the carbonyl oxygen and the amide hydrogen experience significant steric clashing with other atoms in the backbone. These steric repulsions make such conformations energetically unfavorable and structurally disallowed in the folded state of most proteins.

33. (A) The linear sequence of amino acids linked by peptide bonds
Protein architecture is organized into distinct levels of complexity. The primary level refers exclusively to the covalent arrangement of amino acids within the chain. This linear sequence, determined by the genetic code, is maintained by peptide bonds between adjacent residues. It provides the fundamental information required for the protein to fold into its functional three-dimensional shape, including the positions of disulfide bridges.

34. (C) Phenylisothiocyanate (PITC)
Determining the sequence of a protein requires a method to identify residues one by one. The Edman degradation employs phenylisothiocyanate to react with the uncharged N-terminal amino group. Under mild conditions, this labels the terminal residue and allows its selective removal without hydrolyzing the remaining peptide bonds. This cyclical process enables researchers to deduce the amino acid sequence from the N-terminus.

35. (D) A is false but R is true.
Sanger's reagent, or 1-fluoro-2,4-dinitrobenzene, is used to identify the N-terminal amino acid of a protein. It reacts with the terminal amino group to form a stable dinitrophenyl derivative. However, the subsequent hydrolysis required to release the labeled residue breaks all other peptide bonds in the chain. Therefore, it cannot be used to determine the full sequence of a long polypeptide in one go.

36. (D) Dansyl chloride method
The identification of the N-terminal amino acid can be achieved using various chemical labels. Dansyl chloride reacts with the primary amino group to form a highly stable sulfonamide derivative. A key advantage of this method is the intense fluorescence of the resulting dansyl-amino acid. This high sensitivity allows for the detection and identification of the N-terminus even when only minute quantities are available.

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55. (A) P-4, Q-2, R-1, S-3
Protein detection and purification methods rely on various chemical and physical properties. UV absorbance at 280 nanometers detects aromatic residues, while the Biuret test identifies peptide bonds through copper complexation. The Ninhydrin reaction targets free amino groups to produce a colored product. Finally, salting out exploits the differential solubility of proteins in high salt environments to achieve separation from a mixture.

56. (A) The presence of two or more peptide bonds
The Biuret test is a chemical assay used to detect the presence of proteins in a sample. It involves the reaction of copper ions with the nitrogen atoms found in the peptide backbone under alkaline conditions. Because the formation of the colored complex requires at least two peptide bonds, this test is specific for polypeptides and proteins rather than individual amino acids.

57. (B) Ruhemann's Purple
Ninhydrin is a powerful oxidizing agent used to detect amino acids. When it reacts with a primary amino group, it undergoes a series of reactions that result in the formation of a deep blue or purple pigment known as Ruhemann's Purple. This characteristic color is produced by almost all amino acids, although proline produces a yellow color due to its structure.

58. (B) Secondary, tertiary, and quaternary structures without breaking peptide bonds
Denaturation is the process by which a protein loses its functional three-dimensional shape due to external stress. This involves the disruption of the non-covalent interactions and disulfide bonds that maintain the secondary, tertiary, and quaternary levels of organization. Importantly, the primary structure remains intact during this process, as the covalent peptide bonds are not broken by standard denaturing agents.

59. (A) Urea
Chaotropic agents are substances that disrupt the stability of biological macromolecules by interfering with non-covalent interactions, particularly hydrogen bonds and the hydrophobic effect. Urea is a common chaotropic agent used in laboratories to denature proteins. By increasing the solubility of nonpolar groups and competing for hydrogen bonding sites, it causes the protein to unfold into a random coil conformation.

60. (A) I, II and III
Christian Anfinsen used Ribonuclease A to demonstrate that protein folding is spontaneous. He employed urea to disrupt non-covalent bonds and beta-mercaptoethanol to reduce disulfide bridges. Upon removing these agents, the protein refolded into its active native state. This showed that the primary sequence contains all the information needed for folding, proving that chaperones are not always mandatory for this process.

61. (D) The native structure of a protein is determined solely by its amino acid sequence.
The thermodynamic dogma of protein folding suggests that the native structure of a protein represents a global minimum in free energy. This means that for a given environment, the three-dimensional conformation is determined solely by the linear sequence of amino acids. This principle highlights the fundamental link between genetic information and the functional shapes of the molecules that carry out life.

62. (C) Cooperative transition from folded to unfolded state at T_m
Globular proteins typically exhibit a sharp transition from a folded to an unfolded state as the temperature increases. This process is cooperative, meaning that the loss of structure in one part of the molecule destabilizes the rest. The temperature at which half of the protein is denatured is called the melting temperature. This transition involves the sudden collapse of non-covalent interactions.

NODIA

63. (B) Consist of single secondary structural elements arranged in long strands or sheets
Unlike globular proteins, which fold into compact shapes, fibrous proteins serve structural roles and are generally insoluble in water. They are composed of repetitive sequences that form long strands or sheets, consisting of a single type of secondary structure. These proteins, such as keratin and collagen, provide mechanical strength and flexibility to various tissues throughout the body of an organism.

64. (D) $(Gly - X - Y)_n$, where X is often Proline and Y is often Hydroxyproline
Collagen is the most abundant protein in mammals and possesses a unique triple-helical structure. This architecture is made possible by a repetitive primary sequence where every

46. (C) Non-covalent interactions (e.g., hydrophobic, ionic)
Large proteins are often composed of several distinct domains that must be held together to form the functional tertiary structure. These domains are typically linked by flexible segments of the polypeptide chain and are stabilized by various non-covalent interactions. Hydrophobic effects, ionic salt bridges, and hydrogen bonds between the surfaces of the domains ensure they maintain their relative spatial arrangement.

47. (B) They provide a protected environment that prevents protein aggregation during folding.
Although the information for protein folding is contained in the amino acid sequence, the process can be complicated by the high concentration of proteins in the cell. Molecular chaperones are specialized proteins that assist this process by binding to unfolded or partially folded chains. They provide a shielded environment that prevents improper interactions and aggregation, ensuring the protein reaches its native state.

48. (D) Hydrogen bonds - Interaction between non-polar side chains
The tertiary structure is stabilized by several types of chemical forces. Covalent disulfide bonds link cysteine residues, while ionic bonds form between oppositely charged groups. Hydrophobic interactions drive nonpolar groups together to increase water entropy. However, hydrogen bonds occur between polar groups, such as the hydrogen of an amide and the oxygen of a carbonyl, rather than between non-polar side chains.

49. (A) An increase in the entropy of the surrounding water molecules
When a protein folds, the polypeptide chain becomes more ordered, which represents a decrease in entropy. However, the process is spontaneous because of the hydrophobic effect. The burial of nonpolar side chains releases structured water molecules into the bulk solvent, causing a large increase in the entropy of the surrounding water. This net gain in total entropy drives the folding process.

50. (C) A true but R is false.
Many functional proteins are composed of two or more polypeptide chains, known as subunits, which associate in a specific spatial arrangement. This organization is referred to as the quaternary structure. While this level of complexity is common, it is not universal; many proteins, such as myoglobin or ribonuclease, consist of a single polypeptide chain and are fully functional in their tertiary state.

51. (A) Multiple non-covalent interactions
In proteins with quaternary structure, the individual subunits must remain associated to function correctly. This assembly is primarily maintained through the same set of non-covalent forces that stabilize the tertiary structure, including hydrophobic interactions, hydrogen bonds, and ionic attractions. In some specific cases, interchain disulfide bonds may also be present, but multiple non-covalent interactions are the most common stabilizing force.

52. (D) C_2 rotational symmetry
Identical subunits in an oligomeric protein often arrange themselves in a symmetrical fashion to maximize stable interactions. For a dimer consisting of two identical subunits, the most common arrangement is C_2 rotational symmetry. In this configuration, one subunit can be superimposed onto the other by a 180-degree rotation around a central axis, creating a balanced and energetically favorable protein complex.

53. (B) Low to moderate salt concentrations increase the solubility of a protein.
The solubility of a protein is influenced by the concentration of dissolved salts. At low salt concentrations, the ions interact with the charged groups on the protein surface, which helps to shield these charges and prevent the proteins from aggregating. This phenomenon increases the solubility of the protein in the aqueous environment and is traditionally referred to as the "salting in" effect.

54. (C) Salting out
When the concentration of salt, such as ammonium sulfate, becomes very high, the salt ions compete with the protein molecules for available water of hydration. As the water is diverted to solvate the salt ions, the hydrophobic patches on the protein surfaces are exposed, leading to aggregation and precipitation. This method is widely used for the initial purification of proteins.

NODIA

2011

285. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option.

Assertion (A): Chaperones do not dictate the final three-dimensional fold of a protein.

Reason (R): The final native tertiary structure of a protein is determined solely by its primary amino acid sequence.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

286. Which chemical bond provides the most significant resistance against extreme pH changes and thermal denaturation in some extracellular proteins?

(A) Hydrogen bonds
(B) Hydrophobic interactions
(C) Disulfide bonds
(D) Ionic interactions

2019

287. Which of the following methods identifies the C-terminal amino acid by heating the peptide with anhydrous hydrazine to cleave all peptide bonds into amino acid hydrazides except the C-terminal one?

(A) Edman degradation
(B) Sanger method
(C) Akabori hydrazinolysis
(D) Carboxypeptidase digestion

2024

288. A Ramachandran plot identifies structurally disallowed regions based on:

(A) The electronegativity of the side chains
(B) The solubility of the amino acid sequence
(C) The net charge of the polypeptide
(D) The steric hindrance (clashing) between atoms of the polypeptide backbone and side chains

2011

289. The structure of alpha-keratin is best described as:

(A) Two right-handed alpha-helices wrapped around each other in a left-handed coiled-coil
(B) A bundle of strictly parallel beta-sheets
(C) A triple-helical structure rich in proline and glycine
(D) A randomly coiled globular protein

2009

290. Consider the following statements about DNA thermal denaturation:

I. It is fully reversible under slow cooling conditions (annealing).
II. It results in a decrease in UV absorbance at 260 nm.
III. It breaks the covalent phosphodiester bonds.

Which of the above statement(s) is/are correct?

(A) Only I
(B) I and II
(C) II and III
(D) I and III

2003

291. What is the fundamental difference between the core structure of A-DNA and Z-DNA?

(A) A-DNA has a right-handed helix, whereas Z-DNA has a left-handed helix.
(B) A-DNA has 12 base pairs per turn, whereas Z-DNA has 10.
(C) A-DNA is found naturally only in prokaryotes, whereas Z-DNA is exclusively eukaryotic.
(D) A-DNA lacks hydrogen bonds.

2003

292. How does 2,3-bisphosphoglycerate (2,3-BPG) structurally interact with hemoglobin?

(A) It covalently modifies the N-termini of the beta chains.
(B) It acts as a competitive inhibitor by binding directly to the heme iron.
(C) It replaces the oxygen in the oxygen-binding pocket.
(D) It binds via electrostatic interactions to the central cavity of the deoxygenated T-state.

2012

293. Which statement accurately describes a key feature of the transfer RNA (tRNA) tertiary structure?

(A) It forms a long, linear double helix.
(B) It folds into a compact L-shape maintained by complex base-pairing and stacking.
(C) It consists predominantly of a large beta-barrel.
(D) It lacks any chemically modified bases.

2019

294. Analytical ultracentrifugation is a classical technique used to determine which fundamental property of biomacromolecules?

(A) The precise nucleotide sequence of RNA

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third residue is glycine. The sequence is typically represented as $Gly-X-Y$, where X is often proline and Y is frequently hydroxyproline. This arrangement allows the three chains to pack tightly together, providing exceptional tensile strength.

65. (A) Both A and R are true and R is the correct explanation of A.
Vitamin C is an essential cofactor for the enzyme prolyl hydroxylase, which adds hydroxyl groups to proline residues in collagen. These hydroxyl groups are necessary for the formation of hydrogen bonds that stabilize the collagen triple helix. Without sufficient Vitamin C, collagen becomes structurally weak, leading to the symptoms of scurvy, including fragile blood vessels and impaired wound healing.

66. (C) Coiled-coil structures stabilized by numerous disulfide bonds
Alpha-keratin is the primary protein found in hair, nails, and the outer layer of skin. Its structure consists of alpha-helices that wrap around each other to form coiled-coils. The mechanical strength and rigidity of these fibers are derived from the extensive network of covalent disulfide bonds that cross-link the adjacent polypeptide chains, making the material tough and resistant to degradation.

67. (A) Desmosine cross-links
Elastin is a connective tissue protein that allows tissues to resume their shape after stretching. Its characteristic elasticity is due to a highly cross-linked network formed from its precursor, tropoelastin. The most distinctive cross-links in elastin are desmosine molecules, which are formed from the condensation of four lysine side chains. These covalent bonds create a resilient, rubber-like structure within the matrix.

68. (D) Globular proteins possess complex tertiary structures, whereas fibrous proteins generally lack complex tertiary folding.
Globular and fibrous proteins differ significantly in their solubility and structural complexity. Globular proteins are usually soluble and possess intricate tertiary structures that allow them to function as enzymes or transporters. In contrast, fibrous proteins are typically insoluble and consist of long, repeating secondary structural elements. They provide mechanical support and lack the complex, compact folding seen in globular proteins.

69. (B) Asparagine
Glycosylation is a common post-translational modification where carbohydrate chains are attached to proteins. In N-linked glycosylation, the sugar moiety is covalently bonded to the nitrogen atom of an asparagine side chain. This process occurs specifically when the asparagine is part of a consensus sequence, typically $Asn-X-Ser$ or $Asn-X-Thr$, where X can be any amino acid except for proline.

70. (A) P-4, Q-3, R-1, S-2
Many proteins function in association with non-protein components called prosthetic groups. Lipoproteins are complexes that include lipid molecules, while glycoproteins contain attached carbohydrate chains. Nucleoproteins consist of proteins bound to nucleic acids, such as DNA or RNA. Phosphoproteins are modified by the addition of phosphate groups to specific residues. These associations are vital for diverse biological activities of these molecules.

71. (D) Serine and Threonine
Carbohydrates can be attached to proteins through the oxygen atom of specific amino acid side chains. This O-linked glycosylation predominantly involves the hydroxyl groups found in serine and threonine residues. Unlike N-linked glycosylation, which occurs in the endoplasmic reticulum, O-linked modifications typically take place in the Golgi apparatus and are important for protein stability, recognition, and cellular signaling processes.

72. (A) HDL (High-Density Lipoprotein)
Lipoproteins are categorized by their density, which is determined by the relative proportions of lipids and proteins. High-density lipoprotein contains the highest percentage of protein and the lowest percentage of lipids among the various classes. Because proteins are denser than lipids, the high protein-to-lipid ratio in HDL results in its higher buoyant density compared to chylomicrons, VLDL, and LDL.

73. (D) Both (A) and (B)
Nucleoproteins are essential complexes formed by the association of proteins with nucleic acids. In eukaryotic cells, chromatin is a prime example, consisting of genomic DNA wrapped

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around histone proteins to organize the genetic material. Ribosomes also represent functional nucleoprotein complexes, where ribosomal RNA and proteins work together to catalyze protein synthesis. Both structures are fundamental to gene expression.

74. (B) Two identical heavy chains and two identical light chains
The basic unit of an immunoglobulin molecule is a Y-shaped structure composed of four polypeptide chains. This includes two identical heavy chains and two identical light chains, which are linked together by covalent disulfide bonds. Each chain contains both variable and constant regions, which collectively allow the molecule to recognize specific antigens and mediate various effector functions within the immune system.

75. (A) I, II and III
Immunoglobulins are divided into five classes with distinct roles. IgG is the most prevalent antibody in human serum and provides long-term immunity. IgA is found in high concentrations in secretions like saliva and breast milk to protect mucosal surfaces. IgM is the first antibody produced during an infection and typically exists as a pentamer, while IgE is involved in allergies.

76. (C) The variable regions of both heavy and light chains (Fab)
The specificity of an antibody for its target antigen is determined by the variable regions located at the tips of the Y-shaped molecule. Both the heavy and light chains contribute variable domains that form the antigen-binding site, also known as the Fab region. The unique amino acid sequences in these areas allow the immune system to recognize a vast array of pathogens.

77. (D) IgG
Neonatal immunity is supported by the transfer of maternal antibodies across the placenta during pregnancy. Among the five classes of immunoglobulins, only IgG is actively transported from the mother's circulation to the fetus. This process provides the newborn with passive protection against various infections during the first few months of life, until its own immune system becomes fully functional.

78. (C) The amino acid sequence of the heavy chain constant region
The classification of immunoglobulins into types such as IgG, IgA, or IgM is determined by the structure of their heavy chains. Specifically, the amino acid sequence of the heavy chain constant region defines the isotype and dictates the biological properties and effector functions of the antibody. While the variable regions determine antigen binding, the constant regions determine how the antibody interacts.

79. (B) Store oxygen and facilitate its diffusion in muscle cells
Myoglobin is a specialized oxygen-binding protein found in high concentrations within skeletal and cardiac muscle tissues. Its primary role is to serve as a reservoir for oxygen, storing it until the muscle cells require it during intense physical activity. By facilitating the diffusion of oxygen from the blood into the mitochondria, myoglobin ensures a steady supply of energy for muscle contraction.

80. (A) I, III and V
Myoglobin is a monomeric protein that consists of a single polypeptide chain and a heme prosthetic group. Unlike hemoglobin, it does not exhibit cooperative binding, and its oxygen dissociation curve is hyperbolic rather than sigmoidal. Because of its high affinity for oxygen at low partial pressures, it is ideally suited for storing oxygen within muscle cells and releasing it during metabolic demand.

81. (A) Hyperbolic
The relationship between the partial pressure of oxygen and the saturation of myoglobin is represented by a hyperbolic curve. This mathematical shape indicates that myoglobin binds oxygen independently at its single binding site, without the cooperative interactions seen in multi-subunit proteins. Consequently, myoglobin reaches high saturation even at relatively low oxygen levels, which is essential for its storage function.

82. (C) Fe^{2+} (Ferrous)
The ability of hemoglobin and myoglobin to bind oxygen reversibly depends on the presence of an iron atom within the heme group. For this binding to occur, the iron must remain in the ferrous state. If the iron is oxidized to the ferric state, the protein loses its ability to bind oxygen,

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illustrating the importance of maintaining the correct oxidation state.

83. (A) Is oxidized to the Fe^{3+} state, rendering it unable to bind oxygen
Metmyoglobin is an inactive form of the muscle protein myoglobin that is produced when the central ferrous iron of the heme group is oxidized to the ferric state. This change in oxidation state prevents the molecule from binding oxygen, rendering it physiologically non-functional. The formation of metmyoglobin can occur spontaneously or as a result of exposure to certain oxidizing agents.

84. (D) Two alpha chains and two beta chains
Adult human hemoglobin, also known as HbA, is a heterotetramer composed of four polypeptide subunits. The most common form in healthy adults consists of two alpha-globin chains and two beta-globin chains. Each of these subunits contains a heme group with a central iron atom, allowing a single hemoglobin molecule to transport up to four oxygen molecules through the circulatory system.

85. (A) $I \backslash toII \backslash toIII \backslash toIV$
The transition of hemoglobin from a low-affinity to a high-affinity state involves a sequence of structural changes. Initially, the protein exists in the tense T-state. Upon binding the first oxygen molecule, the structure begins to shift, leading to the disruption of stabilizing salt bridges between subunits. These changes facilitate the transition into the relaxed R-state, which has higher oxygen affinity.

86. (C) Positive cooperativity in oxygen binding
Hemoglobin exhibits a sigmoidal oxygen-binding curve, which is a hallmark of allosteric regulation. This shape reflects positive cooperativity, where the binding of an oxygen molecule to one subunit induces conformational changes that increase the affinity of the remaining subunits for oxygen. This property allows hemoglobin to efficiently load oxygen in the lungs and effectively release it where levels are low.

87. (D) Decreases with lower pH and higher carbon dioxide
The Bohr effect describes how the environment influences oxygen delivery. In tissues where metabolism is high, the production of carbon dioxide and protons leads to a decrease in pH. These conditions promote the release of oxygen from hemoglobin by stabilizing the low-affinity T-state. Consequently, the oxygen-binding curve shifts to the right, ensuring that oxygen is delivered where it is needed.

88. (A) Binds and stabilizes the T state, decreasing oxygen affinity
2,3-bisphosphoglycerate is a small organic molecule that plays a critical role in regulating hemoglobin's oxygen affinity. It binds to the central cavity of the hemoglobin tetramer, specifically stabilizing the deoxygenated T-state through electrostatic interactions. By favoring the T-state over the R-state, 2,3-BPG reduces the overall affinity for oxygen, which facilitates the unloading of oxygen to the tissues.

89. (B) Reduced binding of 2,3-BPG due to altered gamma chain residues
Fetal hemoglobin has a higher affinity for oxygen than adult hemoglobin, which allows the fetus to extract oxygen from the maternal blood. This difference arises because the gamma chains in HbF have a lower affinity for 2,3-bisphosphoglycerate compared to the beta chains in HbA. With less 2,3-BPG bound to stabilize the T-state, HbF remains more frequently in the high-affinity state.

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90. (A) I, II and III
Hemoglobin is regulated by several allosteric effectors that modulate its oxygen affinity. Protons and carbon dioxide act as negative effectors by stabilizing the T-state, while oxygen itself acts as a positive homotropic effector through cooperative binding. However, 2,3-bisphosphoglycerate decreases oxygen affinity rather than increasing it. Therefore, only the statements regarding protons, carbon dioxide, and oxygen are correct.

91. (A) A nitrogenous base and a pentose sugar
Nucleic acids are built from fundamental subunits called nucleotides. A nucleoside is a specific part of this structure, consisting of a nitrogenous base covalently linked to a five-carbon pentose sugar, such as ribose or deoxyribose. When a phosphate group is added to the sugar of a nucleoside, the resulting molecule is then classified as a nucleotide building block.

92. (C) Uracil
The nitrogenous bases in nucleic acids are categorized as purines or pyrimidines. While both DNA and RNA contain the pyrimidine cytosine, they differ in their second pyrimidine. DNA uses thymine, whereas RNA incorporates uracil. Adenine and guanine are purines found in both types of nucleic acids. Therefore, uracil is the specific pyrimidine base that is characteristic of ribonucleic acid.

93. (D) β-N-glycosidic bond
In both nucleosides and nucleotides, the nitrogenous base is attached to the pentose sugar via a specific covalent linkage. This bond forms between the C-1' carbon of the sugar and either the N-1 nitrogen of a pyrimidine or the N-9 nitrogen of a purine. This linkage is specifically known as a β-N-glycosidic bond, which provides the structural foundation for nucleic acids.

94. (C) C-2'
The two types of nucleic acids, DNA and RNA, are named after the specific pentose sugars they contain. Ribose, found in RNA, has a hydroxyl group attached to the C-2' carbon. In contrast, deoxyribose, found in DNA, lacks this oxygen atom, having only a hydrogen atom at the C-2' position. This small structural difference has significant effects on stability.

95. (A) I, II, III and IV
Purines like adenine and guanine feature a double-ring structure, while pyrimidines have a single ring. Thymine is distinguished from uracil by the presence of a methyl group. Nucleotides are the phosphorylated versions of nucleosides, usually with the phosphate attached to the 5'-carbon rather than the 2'-carbon. Understanding these structural details is essential for grasping how genetic information is encoded.

96. (D) Non-standard base pairing and spontaneous mutations
Nitrogenous bases can exist in different chemical forms called tautomers, which differ in the positions of their protons and double bonds. Although the keto and amino forms are standard, spontaneous shifts to enol or imino forms can occur. These alternative tautomers change the hydrogen bonding patterns of the bases, potentially leading to incorrect base pairing and resulting in spontaneous mutations.

97. (A) Conjugated double-bond systems of purine and pyrimidine bases
Nucleic acids strongly absorb ultraviolet light, with a maximum absorbance near 260 nanometers. This physical property is primarily due to the electronic structure of the purine and pyrimidine bases, which contain conjugated double-bond systems within their rings. This absorbance is frequently measured in the laboratory to quantify the amount of DNA or RNA in a sample and to assess purity.

98. (C) Negatively charged, making nucleic acids polyanions
The backbone of nucleic acids is composed of alternating sugar and phosphate groups. At physiological pH, the phosphate groups are deprotonated and carry a negative charge. This makes DNA and RNA molecules highly polar and polyanionic. The negative charges on the backbone are often neutralized by interacting with positively charged ions or proteins, such as histones, to stabilize the structure.

99. (C) Three
The stability of the DNA double helix is maintained by specific hydrogen bonds between complementary nitrogenous bases. According to the rules established by Watson and Crick, adenine pairs with thymine using two hydrogen bonds. In contrast, guanine and cytosine form a more stable pair held together by three hydrogen bonds. This higher number of bonds makes G-C rich regions more stable.

100. (B) $II \backslash to I \backslash to IV \backslash to III$
Thermal denaturation of DNA is a multi-step process. As the temperature rises, the hydrogen bonds between complementary base pairs are broken first. This loss of base pairing leads to the unstacking of the aromatic rings, which causes a significant increase in UV absorbance at 260 nanometers. Finally, the two strands separate completely, resulting in a transition from double to single.

101. (B) B-DNA
DNA can adopt several different structural conformations depending on its environment. The B-DNA form is the standard model described by James Watson and Francis Crick. It is a right-handed double helix that is most stable under physiological conditions, such as high hydration and low ionic strength. This conformation is the

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predominant form of the genetic material within living cells.

102. (C) 10.5
The B-form of the DNA double helix is characterized by its regular geometry. In this conformation, one complete turn of the helix covers a distance of approximately 36 Angstroms. This turn includes approximately 10.5 base pairs, meaning each base pair is rotated by about 34 degrees relative to the next. This arrangement results in the characteristic major and minor grooves of DNA.

103. (D) It possesses a left-handed helical rotation.
Z-DNA is a distinct structural form of DNA that differs significantly from the more common B-form. It is characterized by a left-handed helical rotation and a zig-zag appearance of its phosphate backbone. This conformation is often favored by sequences with alternating purines and pyrimidines, such as poly-GC tracts, and is thought to play a role in regulating gene expression.

104. (A) A-DNA
While B-DNA is the standard physiological form, DNA can shift into the A-form under conditions of reduced hydration or high salt concentration. A-DNA is also a right-handed helix, but it is shorter and wider than the B-form, with base pairs that are tilted relative to the helix axis. This conformation is also typically adopted by double-stranded RNA molecules.

105. (A) *I\toII\toIII*
The structure of B-DNA is defined by several key physical parameters. The smallest of these is the rise per base pair, which is approximately 3.4 Angstroms. The diameter of the helix is larger, measuring about 20 Angstroms. The pitch, or the distance required for one complete turn of the helix, is the largest parameter, spanning approximately 34 to 36 Angstroms.

106. (B) Offer specific sequence-dependent binding sites for regulatory proteins
The twisting of the two strands in the DNA double helix creates two distinct channels known as the major and minor grooves. These grooves are biologically important because they expose the edges of the nitrogenous bases to the surrounding environment. This allows regulatory proteins to recognize and bind to specific DNA sequences through hydrogen bonding without unwinding the helical structure.

107. (A) mRNA
Messenger RNA is a single-stranded molecule that serves as the bridge between the genetic information stored in DNA and the protein-synthesizing machinery of the cell. It is produced through transcription and carries the specific sequence of codons that dictate the order of amino acids in a polypeptide. Once in the cytoplasm, mRNA is translated by ribosomes to produce proteins.

108. (C) Transfer RNA
Transfer RNA molecules have a characteristic cloverleaf secondary structure, which is formed by localized base-pairing within the single-stranded chain. This structure includes several distinct loops, such as the anticodon loop and the D-loop, as well as an acceptor stem. This organization is essential for the role of tRNA in matching specific amino acids to their corresponding mRNA codons.

109. (D) The 3'-CCA terminus
During protein synthesis, transfer RNA molecules carry amino acids to the ribosome. The amino acid is covalently attached to the tRNA at a specific site known as the acceptor stem. This site is located at the 3'-terminal end of the molecule, which always ends in the sequence CCA. The carboxyl group of the amino acid forms an ester bond.

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110. (A) I, II, IV and V
Most cellular RNA is ribosomal RNA, which forms the core of the ribosome. Transfer RNA, which adopts an L-shaped tertiary structure, uses its anticodon to pair with mRNA codons. Some RNA molecules, known as ribozymes, have the ability to catalyze chemical reactions. While tRNA contains many modified bases, mRNA is typically not characterized by a high frequency of modifications.

111. (B) Peptidyl transferase center of the ribosome
Ribozymes are RNA molecules that exhibit catalytic activity, challenging the traditional view that all enzymes are proteins. A primary example is the peptidyl transferase center located within the large subunit of the ribosome. This catalytic RNA is responsible for forming the peptide bonds between amino acids during

130. (B) Three
The number of fragments generated by a restriction enzyme digestion depends on whether the DNA is linear or circular. For a circular DNA molecule, such as a plasmid, each cut produces a single linear fragment. Therefore, if a plasmid has three recognition sites for a particular enzyme, the digestion will result in the formation of exactly three separate DNA fragments.

131. (A) The pH at which a molecule has a net charge of zero
The isoelectric point of a molecule is the specific pH at which it carries no net electrical charge. At this pH, the number of positive charges on the molecule is exactly balanced by the number of negative charges. This property is significant because it affects the solubility and electrophoretic mobility of proteins and amino acids in various biological and laboratory systems.

132. (D) Protonation of specific histidine residues stabilizing the T-state
The Bohr effect is a physiological mechanism that enhances oxygen delivery to tissues. It is caused by the protonation of specific amino acid residues, particularly histidine, in the hemoglobin subunits as the pH decreases. These protons help to form and stabilize salt bridges that maintain the low-affinity T-state, thereby promoting the release of oxygen where it is needed most in tissues.

133. (B) Proline is frequently found in the middle of standard alpha-helices because it stabilizes the turn.
Secondary structures like the alpha-helix and beta-sheet are stabilized by specific hydrogen bonding patterns. While glycine and proline are often found in beta-turns, proline is rarely found in the middle of an alpha-helix. Its rigid ring structure and lack of an amide hydrogen for bonding cause it to act as a "helix breaker," introducing a kink that destabilizes the structure.

134. (C) The hydrophobic effect
The folding of a globular protein into its native conformation is driven by several thermodynamic forces. Although hydrogen bonds and ionic interactions contribute to the stability of the final structure, the most significant energetic driving force is the hydrophobic effect. The burial of nonpolar side chains in the protein interior increases the entropy of the surrounding water, making folding favorable.

135. (A) Both A and R are true and R is the correct explanation of A.
The two strands of the DNA double helix are oriented in opposite directions, a configuration known as antiparallel. In one strand, the phosphodiester linkages run from the 5' carbon to the 3' carbon, while in the complementary strand, they run from 3' to 5'. This arrangement is essential for the formation of stable hydrogen bonds between the complementary nitrogenous bases.

136. (A) An 11 base pair per turn right-handed helix with tilted base pairs
A-DNA is a structural variant of the DNA double helix that forms under low humidity conditions. It is a right-handed helix with approximately 11 base pairs per turn. Compared to the B-form, A-DNA is shorter and broader, and its base pairs are tilted away from the perpendicular axis of the helix. This form is also typical for double-stranded RNA molecules.

137. (B) Leucine, Isoleucine, Valine
Amino acids are classified based on the chemical nature of their side chains. The non-polar, aliphatic group includes residues such as leucine, isoleucine, and valine. These amino acids have hydrocarbon side chains that lack polar or charged groups, making them hydrophobic. They are frequently found in the interior of proteins, where they contribute to structural stability through hydrophobic interactions.

138. (B) Psi (ψ) versus phi (ϕ) angles
A Ramachandran plot is a fundamental tool in structural biology used to analyze the conformation of protein backbones. It is a two-dimensional graph where the y-axis represents the psi dihedral angle and the x-axis represents the phi dihedral angle. The plot highlights the combinations of these angles that are sterically allowed, providing insight into the secondary structures in the protein.

139. (A) Isoelectric focusing
Isoelectric focusing is a specialized electrophoretic technique used to separate proteins based on their isoelectric points. A pH gradient is established within a gel, and when an electric field is applied, each protein migrates until it reaches the pH that

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121. (B) The 3'-hydroxyl group
The Sanger method of DNA sequencing utilizes modified nucleotides known as dideoxynucleoside triphosphates. Unlike standard deoxynucleotides, ddNTPs lack the hydroxyl group at the 3'-carbon position of the pentose sugar. In addition to missing the 2'-hydroxyl group found in ribose, the absence of the 3'-OH is critical because it prevents the formation of a phosphodiester bond with the next nucleotide.

122. (B) Immediate chain termination
During DNA synthesis in a sequencing reaction, DNA polymerase incorporates nucleotides into a growing strand. If the enzyme adds a dideoxynucleotide instead of a normal deoxynucleotide, the synthesis comes to a sudden halt. This immediate chain termination occurs because the ddNTP lacks the 3'-hydroxyl group required to link to the next nucleotide, resulting in fragments that reveal the sequence.

123. (A) Base-specific chemical cleavage of an end-labeled DNA molecule
The Maxam-Gilbert sequencing method is a chemical approach to determining DNA sequences. It involves labeling one end of a DNA fragment and then subjecting it to various chemical treatments that specifically modify and cleave the DNA at certain bases. By separating the resulting fragments by size, the sequence can be deduced. This differs from the Sanger method's enzymatic synthesis.

124. (C) Dimethyl sulfate (DMS) followed by piperidine
In the Maxam-Gilbert sequencing procedure, specific chemicals are used to target different nitrogenous bases. To cleave the DNA at purine residues, dimethyl sulfate is used to methylate the guanine and adenine bases. This treatment makes the glycosidic bond unstable, allowing the backbone to be broken at these positions using piperidine. This base-specific cleavage is fundamental to generating sequencing fragments.

125. (D) Cleavage of foreign DNA at specific recognition sites
Restriction endonucleases are enzymes produced by bacteria as a defense mechanism against viral infections. These enzymes recognize specific, short sequences of foreign DNA and cut the phosphodiester backbone at or near these sites. By fragmenting the invading genetic material, the bacteria can prevent the virus from replicating. These "molecular scissors" have become indispensable tools in modern recombinant DNA technology.

126. (C) Cleave DNA at predictable positions within or near their specific recognition sequence
Type II restriction endonucleases are the most common tools for genetic engineering because of their predictable behavior. Unlike Type I or Type III enzymes, which cleave DNA at variable distances from their recognition sites and may require ATP, Type II enzymes cut the DNA at specific, fixed positions within or very close to their recognition sequences. This precision allows targeted cloning.

127. (B) Palindromic symmetry (two-fold rotational symmetry)
The recognition sites for many Type II restriction enzymes exhibit twofold rotational symmetry, commonly known as palindromic sequences. In these sequences, the DNA on one strand reads the same as the sequence on the complementary strand when both are read in the 5' to 3' direction. This symmetry allows the enzyme, which often functions as a homodimer, to cut both.

128. (B) 5'-overhanging sticky ends
The restriction enzyme EcoRI recognizes the sequence GAATTC and cleaves the DNA between the G and the A on both strands. Because the cuts are staggered rather than being directly across from each other, the resulting DNA fragments have short, single-stranded 5'-overhanging ends. These "sticky ends" are useful in cloning because they can easily base-pair with complementary sequences on other fragments.

129. (A) Diagram showing relative positions of restriction sites
A restriction map is a graphical representation of a DNA molecule that shows the locations of specific restriction enzyme recognition sites. By digesting the DNA with various enzymes and analyzing the sizes of the resulting fragments, researchers can determine the relative distances between these sites. This map serves as a valuable tool for characterizing DNA fragments and planning further genetic experiments.

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translation, demonstrating the fundamental role of RNA in basic life processes.

112. (D) Increased UV absorbance at 260 nm upon DNA denaturation
The hyperchromic effect is a physical phenomenon observed when double-stranded DNA is denatured into single strands. In the double helix, the aromatic rings of the bases are stacked, which partially masks their ability to absorb light. When the strands separate, this stacking is lost, leading to a significant increase in the ultraviolet light absorbance at 260 nanometers in solution.

113. (A) A molecule with 70% G-C content
The thermal stability of a DNA molecule is largely determined by its base composition. Guanine and cytosine pairs are held together by three hydrogen bonds, whereas adenine and thymine pairs have only two. Furthermore, G-C pairs have stronger base-stacking interactions. Consequently, DNA molecules with a higher percentage of G-C content require more energy to denature and exhibit higher T_m.

114. (C) Increases T_m by shielding phosphate backbone repulsion
The phosphate backbone of DNA carries negative charges that naturally repel each other, destabilizing the double helix. Adding salts like sodium chloride to the solution provides cations that shield these negative charges, reducing the electrostatic repulsion. This shielding effect stabilizes the double-stranded structure, making it more resistant to thermal denaturation and thereby increasing the measured melting temperature of the DNA.

115. (C) A is true but R is false.
Cot curve analysis measures the rate at which denatured DNA strands reassociate into double helices. This technique is used to estimate the genomic complexity of an organism. While the overall approach is valid, the reasoning must account for the fact that highly repetitive sequences find their complements more quickly than unique sequences. Therefore, repetitive DNA renatures faster, not slower, which increases T_m.

116. (D) Highly repetitive
In a DNA reassociation experiment, the Cot value represents the product of the initial DNA concentration and the time elapsed. A low *Cot* value required for half-renaturation indicates that the DNA strands were able to find their complementary sequences very rapidly. This occurs when a sequence is present in many copies throughout the genome, characterizing the DNA as highly repetitive.

117. (B) Sedimentation velocity under centrifugation relative to the centrifugal field
The Svedberg coefficient is a unit used to describe the sedimentation behavior of particles during ultracentrifugation. It is defined as the ratio of a particle's sedimentation velocity to the acceleration applied by the centrifugal field. This value depends on the mass, density, and shape of the particle, providing information about its size and overall physical properties in a biological sample.

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118. (C) Buoyant density
Isopycnic, or equilibrium, density gradient centrifugation is a technique that separates molecules based on their buoyant density. When a sample is spun at high speeds in a gradient, such as cesium chloride, each molecule will migrate until it reaches a position where its own density matches the density of the surrounding medium. This method is particularly effective for separating DNA types.

119. (D) Cesium chloride (CsCl)
Cesium chloride is the most widely used salt for creating density gradients in isopycnic ultracentrifugation. Because cesium is a heavy atom, a concentrated solution can form a steep and stable density gradient when subjected to high centrifugal forces. This allows for the precise separation of nucleic acids, such as DNA molecules with different G-C contents or different degrees of strandedness.

120. (A) I, II, III
The buoyant density of nucleic acids in a cesium chloride gradient is influenced by their base composition and structure. For double-stranded DNA, the density increases with increasing G-C content because G-C pairs are denser than A-T pairs. Single-stranded RNA is significantly denser than double-stranded DNA due to its different sugar-phosphate backbone and structure, placing it highest in density.

corresponds to its pI. At this point, the protein has no net charge and stops moving, allowing for high-resolution separation.

140. (A) P-2, Q-3, R-4, S-1
Different enzymes catalyze specific modifications to DNA. Restriction endonucleases cleave internal bonds at defined sites, while DNA ligase joins fragments together by forming new phosphodiester linkages. DNA polymerase synthesizes new strands from a DNA template, and reverse transcriptase uses an RNA template to produce complementary DNA. These enzymes are essential for cellular DNA metabolism and widely used in biotechnology.

141. (D) Recognition by the correct aminoacyl-tRNA synthetase
The D-loop is one of the characteristic structural features of the transfer RNA cloverleaf. It contains the modified base dihydrouridine, from which it gets its name. The primary function of the D-loop is to provide a recognition site for the specific aminoacyl-tRNA synthetase enzyme. This interaction ensures that the correct amino acid is attached to the tRNA during charging.

142. (C) Become a random coil
When a protein is treated with high concentrations of urea and a reducing agent like beta-mercaptoethanol, it undergoes complete denaturation. The urea disrupts non-covalent interactions, while the reducing agent breaks disulfide bonds. This process causes the polypeptide chain to lose all its secondary and tertiary structure, resulting in a flexible and disordered conformation known as a random coil.

143. (B) Guanine-Cytosine
The thermal stability of a DNA double helix is influenced by the number of hydrogen bonds between its constituent base pairs. Guanine and cytosine are linked by three hydrogen bonds, whereas adenine and thymine are linked by only two. Because it takes more energy to break three bonds than two, regions rich in G-C pairs require a higher temperature.

144. (D) Nucleotides contain a phosphate group while nucleosides lack one
Nucleosides and nucleotides are the building blocks of nucleic acids, but they differ in their chemical composition. A nucleoside consists of a nitrogenous base attached to a pentose sugar. A nucleotide is formed when one or more phosphate groups are covalently bonded to the sugar of a nucleoside. Therefore, the presence of the phosphate group is the defining feature.

145. (A) It restricts the polypeptide backbone to only a limited number of stable conformations.
The partial double-bond character of the peptide bond makes it rigid and planar, which prevents rotation around the C-N bond. This structural rigidity significantly restricts the number of possible conformations the polypeptide backbone can adopt. Consequently, protein folding is guided by rotations around the alpha-carbon bonds, which are represented by the ϕ and ψ angles in protein structure.

146. (C) The spatial arrangement of subunits changes upon oxygen binding.
Hemoglobin is an allosteric protein whose function is linked to its three-dimensional structure. When oxygen binds to the heme groups, it triggers a conformational shift in the entire tetramer. The individual subunits rotate and slide relative to one another, causing a transition from the tense T-state to the relaxed R-state. This spatial rearrangement is responsible for cooperative oxygen binding.

147. (A) An evolutionarily conserved, independently folded segment of a polypeptide chain
A protein domain is a distinct, compact region of a polypeptide chain that can fold independently into a stable three-dimensional structure. Domains are often associated with specific biological functions, such as binding a ligand or catalyzing a reaction. Many large proteins are composed of multiple domains, which may have evolved through gene duplication and are found in various proteins.

148. (D) They cleave DNA precisely 24–26 base pairs away from the recognition site.
Type III restriction endonucleases are complex enzymes that possess both cleavage and methylation activities. Unlike Type II enzymes, they require ATP for their function and recognize asymmetric sequences. A distinguishing feature of Type III enzymes is that they cleave the DNA at a specific distance, typically 24 to 26 base pairs, away from the recognition site. This is predictable.

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149. (B) To assess the purity of the nucleic acid preparation relative to protein contamination
The purity of a nucleic acid sample is commonly assessed by measuring its absorbance at 260 and 280 nanometers. Nucleic acids absorb strongly at 260 nm, while proteins absorb at 280 nm due to aromatic residues. A ratio of approximately 1.8 for DNA or 2.0 for RNA indicates a clean preparation, while a lower ratio suggests protein contamination.

150. (D) I, II and III
Immunoglobulins are built from discrete structural domains. Each light chain consists of one variable and one constant domain, while each heavy chain has one variable domain and several constant domains. The entire tetrameric structure is stabilized by disulfide bonds, which link the light chains to the heavy chains and the two heavy chains together, forming an antibody.

151. (D) CO binds heme iron with 250 times greater affinity than oxygen
Carbon monoxide is a dangerous toxin because it competes with oxygen for binding sites on hemoglobin. The affinity of hemoglobin for CO is approximately 250 times greater than its affinity for oxygen. Once bound, CO not only prevents oxygen transport but also increases the affinity of the remaining subunits for oxygen, hindering its release and leading to tissue hypoxia.

152. (A) Arginine and Lysine
Amino acids with side chains that are positively charged at physiological pH are classified as basic. This group includes arginine, lysine, and histidine. Arginine contains a guanidino group and lysine has an epsilon-amino group, both of which are strongly basic. These residues are often involved in forming ionic interactions with negatively charged molecules, such as the phosphate backbone.

153. (B) Minimal structural disruption due to the conservative nature of the substitution
A mutation that replaces one amino acid with another that has similar chemical properties is called a conservative substitution. Because leucine and isoleucine are both nonpolar, aliphatic amino acids of similar size, replacing one with the other in the hydrophobic core of a protein is unlikely to cause major structural disruption. The protein will generally maintain its overall native fold.

154. (B) The cloverleaf arrangement created by localized base-pairing
The secondary structure of a tRNA molecule is defined by the specific pattern of internal base-pairing between different regions of the single-stranded RNA. This results in the well-known cloverleaf model, which includes several stems and loops. While the actual three-dimensional shape is an L-form, the cloverleaf arrangement is the standard way to represent the secondary level of organization.

155. (A) Mass spectrometry (e.g., MALDI-TOF)
Mass spectrometry is a powerful analytical technique used to determine the molecular weight of large biomolecules with high precision. It works by ionizing the molecules and measuring their mass-to-charge ratio in a vacuum. Methods like MALDI-TOF are specifically designed for proteins and other macromolecules, providing accurate information for identification, sequencing, and the detection of post-translational modifications in samples.

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156. (C) 50% of the double-stranded DNA has denatured into single strands
The melting temperature is a fundamental characteristic of a DNA molecule. It is defined as the temperature at which exactly half of the double-stranded DNA in a sample has denatured into single strands. This point corresponds to the midpoint of the hyperchromic shift, providing a measurable value that reflects the overall thermal stability and base composition of DNA.

157. (D) 5'-ATCGAT-3'
Type II restriction endonucleases typically recognize short, palindromic DNA sequences. In a palindrome, the sequence is identical when read 5' to 3' on both complementary strands. An example of such a sequence is 5'-ATCGAT-3', where the opposite strand also reads 5'-ATCGAT-3'. These symmetric sites allow the dimeric enzyme to bind and cut both strands of the DNA.

158. (C) Positive cooperativity
The binding of oxygen to hemoglobin is a classic example of positive cooperativity. This process means that the binding of the first oxygen molecule to one of the four subunits induces a conformational change that increases the affinity of the other subunits for oxygen. This effect results in the characteristic sigmoidal binding

curve, allowing hemoglobin to respond sensitively to oxygen levels.

159. (B) Phosphodiester bond
The primary structure of a nucleic acid is the linear sequence of nucleotides that make up the polymer. These subunits are linked together by covalent 3',5'-phosphodiester bonds, which form the continuous sugar-phosphate backbone of the molecule. While hydrogen bonds stabilize the double helix, the phosphodiester bonds are responsible for maintaining the integrity of each individual strand of DNA.

160. (D) Gamma-carboxyglutamate
γ-carboxyglutamate is a specialized amino acid formed by the post-translational modification of glutamate residues. This modification, which requires Vitamin K, adds a second carboxyl group to the side chain. This creates a potent binding site for divalent calcium ions, which is essential for the function of several proteins in the blood clotting cascade, such as prothrombin and clotting factors.

161. (A) Both A and R are true and R is the correct explanation of A.
Hemoglobin plays a dual role in the blood as an oxygen transporter and a buffer. By binding to protons and carbon dioxide produced during cellular metabolism, hemoglobin helps to prevent significant changes in blood pH. This buffering capacity is crucial for maintaining homeostasis, especially as the protein transports these metabolic byproducts from the tissues back to the lungs for elimination.

162. (C) One that can act as both an acid and a base
An amphoteric molecule is one that has the ability to act as either an acid or a base depending on the environment. Amino acids are classic examples because they contain both an acidic carboxyl group and a basic amino group. This dual nature allows them to either donate or accept protons, making them effective buffers in various biological systems and environments.

163. (A) One at a time from the N-terminus
Edman degradation is a widely used technique for protein sequencing. It involves a cyclical chemical reaction that specifically removes the amino acid at the amino-terminal end of the polypeptide. The removed residue is then identified, and the process is repeated for the next amino acid. This step-by-step removal from the N-terminus allows for the determination of the protein's sequence.

164. (D) Non-covalent interactions and occasionally interchain disulfide bonds
The quaternary structure of a protein describes how multiple polypeptide subunits are organized into a functional complex. This structure is primarily stabilized by a variety of non-covalent interactions, including hydrophobic effects, hydrogen bonds, and ionic attractions between the subunit surfaces. In some cases, covalent disulfide bonds between different chains also contribute to the stability and permanence of protein assembly.

165. (B) II and III
Protein folding is not a random process but a directed pathway toward the most stable conformation. It often begins with the rapid formation of secondary structures, which then collapse into a partially organized state called a molten globule. The process concludes when the protein reaches its native tertiary structure, which is typically the global minimum of free energy.

166. (C) DNA has a 2'-H, while RNA has a 2'-OH on the pentose ring.
One of the primary differences between DNA and RNA is the type of pentose sugar in their backbone. DNA contains deoxyribose, which has a hydrogen atom at the 2' position. RNA contains ribose, which possesses a hydroxyl group at the same location. This 2'-OH group makes RNA more chemically reactive and less stable than DNA, especially under alkaline conditions.

167. (D) The iron atom moves into the plane of the porphyrin ring.
When oxygen binds to the heme group in hemoglobin, it causes a subtle but critical structural change. In the deoxygenated state, the iron atom sits slightly outside the plane of the porphyrin ring. Oxygen binding pulls the iron into the plane, which in turn moves the attached histidine residue and triggers a conformational shift throughout the entire hemoglobin subunit.

168. (A) 3.4 Angstroms
In the standard B-form of the DNA double helix, the nitrogenous bases are stacked on top of each other. The vertical distance between the centers of these adjacent stacked base pairs

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antigen molecules simultaneously. This ability is important for various immune functions, such as the cross-linking of antigens and the formation of immune complexes.

207. (B) Edman degradation
Edman degradation is a chemical technique used to determine the amino acid sequence of a peptide by sequentially removing residues from the amino-terminal end. By identifying each removed amino acid in order, researchers can reconstruct the primary structure of the molecule. This method is highly effective for short to medium-length peptides and remains a standard tool in protein chemistry.

208. (D) It enzymatically hydrolyzes the peptide bond of the C-terminal amino acid, releasing it for identification.
Carboxypeptidases are enzymes used to identify the amino acid at the C-terminal end of a polypeptide. They function by specifically hydrolyzing the peptide bond of the terminal residue, releasing it into the solution. By analyzing the released amino acids over time, the sequence at the carboxyl terminus can be deduced. This enzymatic approach complements chemical methods that sequence from N-terminus.

209. (A) The enzyme activity per milligram of total protein
The specific activity is a measure of the purity of an enzyme preparation. It is defined as the number of units of enzyme activity per milligram of total protein in the sample. As an enzyme is purified from a complex mixture, its specific activity increases because the amount of contaminating protein decreases. This value is essential for monitoring purification.

210. (A) P-2, Q-3, R-4, S-1
Each amino acid has a unique side chain that defines its properties. Tryptophan is characterized by an indole ring, while cysteine contains a reactive sulfhydryl group. Proline is a cyclic imino acid that restricts backbone rotation. Histidine features an imidazole ring that can participate in catalysis. These structural differences are the basis for the diverse functions and structures of proteins.

211. (A) tRNA
Transfer RNA molecules are the adapters that translate the genetic code into a protein sequence. Each tRNA contains a specific three-nucleotide sequence known as an anticodon, which is located in the anticodon loop. This sequence is complementary to a specific codon on the mRNA, allowing the tRNA to bring the correct amino acid to the ribosome during translation.

212. (D) It is incorporated into the polypeptide chain during translation via a specific tRNA.
Selenocysteine is unique because it is incorporated into proteins during translation rather than being produced by a post-translational modification. It is encoded by the UGA stop codon when a specific structural element is present in the mRNA. A specialized tRNA carries the selenocysteine to the ribosome, allowing it to be added to the growing polypeptide chain directly.

213. (B) Embedded within a lipid bilayer membrane
The environment in which a protein exists strongly influences its amino acid composition. Proteins that are embedded within the lipid bilayer of a cell membrane are surrounded by hydrophobic lipid tails. Therefore, these proteins have a high proportion of hydrophobic amino acids on their surface to allow for stable interactions with the membrane, anchoring the protein in place.

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214. (C) Cysteine
Keratins are the structural proteins that make up hair, nails, and horns. Their strength and rigidity are primarily due to a high content of the sulfur-containing amino acid cysteine. The sulfhydryl groups of these cysteine residues form covalent disulfide bonds between adjacent polypeptide chains. The number of these cross-links determines how hard or flexible the resulting structure will be.

215. (A) I, II and III
Collagen is a major structural protein of the extracellular matrix and is characterized by a triple-helical structure. The sequence features glycine at every third position, which is essential for the tight packing of the helices. Additionally, hydroxyproline is critical for the stability of the structure through hydrogen bonding. Large, bulky amino acids like tryptophan are not characteristic.

aggregating and precipitating, a phenomenon known as salting in.

178. (C) Mass, shape, and density of the particle, and density of the solvent
In an analytical ultracentrifuge, the rate at which a macromolecule moves through a solution is determined by several factors. These include the mass and density of the particle, which drive it downward, and its shape, which affects the frictional resistance it encounters. Additionally, the density of the solvent influences the buoyancy, making the sedimentation rate a complex physical function.

179. (A) Extensive hydrogen bonding and base stacking interactions
The functional three-dimensional shape of a tRNA molecule is maintained by a complex network of non-covalent interactions. While the secondary structure is stabilized by standard Watson-Crick base pairing, the L-shaped tertiary fold is held together by additional hydrogen bonds, many of which involve non-standard base pairs. Base stacking interactions also play a critical role in stabilizing the tRNA structure.

180. (B) I and III
The isoelectric point is a critical parameter for protein stability and purification. At its pI, a protein has no net charge, which leads to a minimum in the electrostatic repulsion between molecules and a corresponding minimum in solubility. Consequently, proteins often aggregate and can be easily precipitated by adjusting the solution pH to their pI, making this a useful purification.

181. (B) Point outward, perpendicular to the central axis
In an alpha-helix, the amino acid side chains, or R-groups, are not part of the internal hydrogen bonding network. Instead, they are oriented away from the helical axis and point outward into the surrounding environment. This arrangement minimizes steric hindrance between the side chains and allows them to interact with other molecules or other parts of the protein's tertiary fold.

182. (C) Formation by segments distant in the primary sequence
Beta-sheets are a common type of protein secondary structure formed by the association of multiple polypeptide strands. Unlike the alpha-helix, which is composed of a continuous local segment of the chain, beta-sheets can be formed by strands that are far apart in the primary sequence. The structure is stabilized by hydrogen bonds between the backbones of adjacent, aligned strands.

183. (D) The light chain alone dictates antigen specificity.
Immunoglobulins are sophisticated molecules designed for antigen recognition. While the Fab region as a whole is responsible for binding, the specificity of an antibody is determined by the variable domains of both the heavy and the light chains. The light chain alone cannot dictate specificity, as the binding pocket is formed by the interaction of both chains together.

184. (A) Antiparallel beta-pleated sheets
Silk fibroin is a fibrous protein produced by silkworms and spiders, known for its exceptional strength and flexibility. Its structure is composed predominantly of antiparallel beta-pleated sheets that are stacked on top of each other. The high content of small amino acids like glycine and alanine allows these sheets to pack tightly together, held by hydrogen bonds and interactions.

185. (C) A true but R is false.
Type II restriction endonucleases are distinct from Type I and Type III enzymes in several ways. While they do recognize and cleave DNA at specific sites, the cleavage and methylation activities are usually performed by separate proteins rather than being part of the same polypeptide chain. The assertion that they cleave near their recognition site is correct, but the reason.

186. (D) 80%
Cells contain several different types of RNA, each serving a unique role in gene expression. Ribosomal RNA is by far the most abundant type, making up approximately 80% of the total RNA in a typical prokaryotic cell. This high proportion reflects the cell's massive investment in the protein-synthesizing machinery, as rRNA forms the structural and catalytic core of ribosomes.

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187. (A) Christian Anfinsen
The relationship between a protein's primary sequence and its final three-dimensional structure was established through the work of Christian Anfinsen. In his landmark experiments with Ribonuclease A, he demonstrated that a denatured protein could spontaneously refold into its active state once the denaturing agents were removed. This finding proved that all information required for folding is inherent in the sequence.

188. (C) Beta-turn (reverse turn)
In compact globular proteins, the polypeptide chain must frequently change direction to fold back on itself. These changes are achieved through small structural elements known as beta-turns or reverse turns. A beta-turn typically involves four amino acid residues and is stabilized by a hydrogen bond between the first and fourth residues. Glycine and proline are often found in these turns.

189. (D) G-C pairs
The stability of the DNA double helix is provided by both hydrogen bonding and base stacking interactions. Base stacking, which is driven by the hydrophobic effect and van der Waals forces, occurs between the flat faces of adjacent base pairs. Because of their electronic structure, G-C base pairs exhibit stronger stacking interactions than A-T pairs, making G-C rich DNA stable.

190. (D) I, II and IV
The synthesis of DNA in living cells requires high-energy building blocks. These precursor molecules are deoxynucleoside triphosphates, which consist of a nitrogenous base, a deoxyribose sugar, and three phosphate groups. During the synthesis process, two of the phosphates are removed, providing the energy needed to form the phosphodiester bond that links the new nucleotide to the growing DNA strand.

191. (B) Base stacking interactions driven by the hydrophobic effect
Although hydrogen bonds provide specificity for base pairing, the primary thermodynamic force driving the formation of the DNA double helix is base stacking. In an aqueous environment, the hydrophobic nitrogenous bases are driven to stack on top of each other to minimize contact with water. This process increases the entropy of the surrounding solvent, making the helical structure energetically favorable.

192. (D) Hydrogen bonds
Denaturation of DNA refers to the separation of the two strands of the double helix. This process involves the disruption of the non-covalent interactions that hold the strands together, most notably the hydrogen bonds between the complementary nitrogenous bases. Importantly, the covalent phosphodiester bonds that form the backbone of each individual strand remain intact, allowing the DNA to renature.

193. (A) Single-stranded overhangs produced by specific restriction enzymes that can form base pairs with complementary sequences
Certain restriction enzymes cut the DNA strands at staggered positions, leaving short, single-stranded overhanging ends. These are known as "sticky ends" because they can form complementary base pairs with similar overhangs on other DNA fragments. In recombinant DNA technology, this property is exploited to easily join different DNA molecules together using the enzyme DNA ligase, facilitating recombinant clone creation.

194. (C) It is a highly compact, globular protein composed mostly of alpha-helices.
Myoglobin is a compact, globular protein that is found in high concentrations in muscle cells. Its three-dimensional structure is composed almost entirely of eight alpha-helices, which are connected by short loops. This compact fold creates a protected pocket for the heme prosthetic group, which is essential for the protein's ability to bind and store oxygen for muscle metabolism.

195. (A) P-3, Q-2, R-4, S-1
Protein structure is maintained by a hierarchy of chemical bonds. Peptide bonds form the primary sequence, while hydrogen bonds stabilize secondary structures like alpha-helices. The hydrophobic effect drives the core packing of the tertiary structure, and disulfide bonds provide covalent cross-links between distant parts of the polypeptide. These forces work together to ensure the protein adopts its fold.

196. (D) Right, indicating decreased affinity
The Bohr effect describes the reduction in hemoglobin's oxygen affinity that occurs in response to increased acidity or carbon dioxide.

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On a graph of oxygen saturation versus partial pressure, this change is represented by a shift of the sigmoidal curve to the right. This shift indicates that a higher partial pressure of oxygen is required to achieve high saturation levels.

197. (B) 2,3-Bisphosphoglycerate (2,3-BPG)
2,3-bisphosphoglycerate is an allosteric regulator that binds to hemoglobin and decreases its affinity for oxygen. By stabilizing the deoxygenated T-state, 2,3-BPG promotes the release of oxygen from hemoglobin into the tissues. This is a critical adaptation for ensuring adequate oxygen delivery, especially under conditions of low oxygen availability, such as at high altitudes or during intense physical exertion.

198. (C) 9.74
Lysine is a basic amino acid with an ionizable side chain. The isoelectric point for such a molecule is calculated by averaging the two pK_a values that correspond to the titration of the neutral form into the zwitterion and then into the negatively charged form. For lysine, these are the pK_a of the α-amino group and the side chain group.

199. (D) Their sedimentation coefficient, which depends on mass, size, and shape
The movement of nucleic acids in an analytical ultracentrifuge is governed by their sedimentation coefficient. This value is a reflection of how fast a molecule moves under a centrifugal force and is influenced by its mass, size, and three-dimensional shape. By analyzing the sedimentation behavior, researchers can determine the molecular weight and purity of DNA and RNA samples accurately.

200. (A) I and III
B-DNA is the most common biological form of the double helix. It is characterized as a right-handed helix with a wide and deep major groove that is accessible to proteins. While the phosphate backbone is on the outside, the nitrogenous bases are oriented toward the interior of the helix. A-DNA is favored in highly dehydrated or low-humidity environments instead.

201. (B) Cytosine
The nitrogenous bases in DNA are subject to various spontaneous chemical changes. One of the most common is the deamination of cytosine, which involves the loss of its amino group. This reaction converts cytosine into uracil, a base that is normally found in RNA but not DNA. If not repaired, this change can lead to a mutation during replication.

202. (B) B-form
Under the conditions typically found within a living cell, such as high hydration and standard ionic strength, double-stranded DNA adopts the B-conformation. This right-handed double helix is the most energetically stable structure for the genetic material and is the form that is recognized and acted upon by most DNA-binding proteins involved in transcription, replication, and repair processes.

203. (B) 5' to 3'
DNA polymerases are enzymes that catalyze the synthesis of new DNA strands by adding nucleotides to a primer. These enzymes always function in the 5' to 3' direction, meaning they add new nucleotides to the 3'-hydroxyl group of the growing chain. This directional requirement is universal across all known organisms and has significant implications for how DNA is replicated.

204. (C) Exonucleases
Exonucleases are a class of enzymes that catalyze the removal of nucleotides from the ends of a DNA or RNA molecule. They can function from either the 5' end or the 3' end, depending on their specific activity. These enzymes play important roles in DNA repair, the processing of recombination intermediates, and the degradation of foreign or damaged genetic material.

205. (A) Both A and R are true and R is the correct explanation of A.
In the early days of genomics, both Maxam-Gilbert and Sanger methods were used for sequencing. However, the Sanger method became the dominant technique because it is enzymatic, easily automated, and does not require the use of highly toxic chemicals like hydrazine or dimethyl sulfate. The scalability of the Sanger method made it the preferred choice for large-scale projects.

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206. (C) The presence of two identical Fab regions
The basic monomeric structure of an immunoglobulin is Y-shaped and contains two identical antigen-binding sites, one at the tip of each Fab arm. This bivalent nature allows a single antibody molecule to bind to two

244. (D) Is a single polypeptide chain (monomer)
Myoglobin and hemoglobin are both oxygen-binding proteins, but they differ in their structural organization. While hemoglobin is a heterotetramer composed of four subunits, myoglobin is a monomer consisting of a single polypeptide chain. This simpler structure means that myoglobin lacks the cooperative binding and allosteric regulation that are characteristic of the multi-subunit hemoglobin molecule found in blood.

245. (A) Both A and R are true and R is the correct explanation of A.
The thermal stability of DNA is directly related to its base composition. Guanine-cytosine pairs are joined by three hydrogen bonds, which are more stable than the two bonds in adenine-thymine pairs. Additionally, G-C pairs have stronger base-stacking interactions. As a result, DNA with a higher G-C content requires a higher temperature to denature, leading to higher T_m.

246. (C) Glutamine
In an aqueous environment, globular proteins fold to minimize the exposure of nonpolar side chains to water. Therefore, hydrophobic amino acids like leucine, isoleucine, and valine are usually buried in the protein interior. In contrast, polar or charged amino acids, such as glutamine, are most likely to be found on the exterior surface, where they can form favorable interactions.

247. (D) The presence of proline or consecutive bulky amino acids
The alpha-helix is a regular secondary structure stabilized by a specific pattern of hydrogen bonding. The formation of this structure can be disrupted by certain amino acids. Proline is a major "helix breaker" because its rigid ring prevents rotation and it lacks an amide hydrogen. Additionally, consecutive bulky or similarly charged amino acids can cause steric or electrostatic repulsion.

248. (A) HbF lacks beta chains, having gamma chains instead.
Fetal hemoglobin and adult hemoglobin are distinguished by their subunit composition. Adult hemoglobin is composed of alpha and beta chains, while fetal hemoglobin consists of alpha and gamma chains. This structural difference is significant because the gamma chains have a lower affinity for 2,3-bisphosphoglycerate, giving HbF a higher overall oxygen affinity that allows it to successfully compete for oxygen.

249. (B) It involves determining the relative positions of restriction sites by analyzing fragment sizes.
Restriction mapping is a technique used to characterize a DNA molecule by identifying the locations of specific recognition sites for restriction enzymes. The process involves measuring the sizes of the fragments produced by enzymatic digestion and using this information to deduce the relative positions of the sites. This resulting map provides a physical blueprint of DNA essential for cloning.

250. (A) P-1, Q-2, R-3, S-4
The different classes of immunoglobulins have unique roles in the immune system. IgG is the primary antibody in the secondary response and can cross the placenta. IgA is the major antibody in external secretions like saliva. IgM is produced first during an infection and forms a pentamer. IgE is specialized for mediating allergic reactions and defense against parasites.

251. (A) High salt concentrations and alternating purine-pyrimidine sequences
Z-DNA is a left-handed double helix that can form under specific conditions. It is stabilized by alternating sequences of purines and pyrimidines, such as poly-GC tracts. High salt concentrations also favor the Z-conformation because the ions shield the phosphate charges, reducing the repulsion that would otherwise destabilize this alternative structure. This form of DNA may regulate gene expression.

252. (C) RNA molecules that possess catalytic activity
Ribozymes are specialized RNA molecules that have the ability to act as biological catalysts. Like protein enzymes, they increase the rate of chemical reactions by lowering the activation energy. Ribozymes play essential roles in several cellular processes, such as RNA splicing and the formation of peptide bonds during translation, demonstrating that RNA can serve both as information and catalyst.

253. (D) Aromatic amino acid residues (Tryptophan, Tyrosine)
Proteins exhibit a characteristic ultraviolet light absorption peak at approximately 280 nanometers. This property is primarily due

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216. (A) Transition between high-affinity and low-affinity states
The sigmoidal shape of the hemoglobin oxygen-binding curve is a direct result of allosteric regulation and cooperative binding. It indicates that the protein can exist in two states: a low-affinity tense state and a high-affinity relaxed state. As oxygen binds, the transition between these states occurs, allowing hemoglobin to effectively transport oxygen by switching between these different binding levels.

217. (B) Glycine
Glycine is the smallest amino acid and has only a hydrogen atom as its side chain. Because of this small size, glycine experiences very little steric hindrance compared to other amino acids. This lack of bulk allows the polypeptide backbone to adopt a much wider range of ϕ and ψ dihedral angles, making glycine a highly flexible residue in proteins.

218. (C) Non-covalent interactions like hydrogen bonds and hydrophobic effects
When a protein is exposed to high temperatures, the increased kinetic energy causes the atoms to vibrate more violently. This eventually leads to the disruption of the weak non-covalent interactions, such as hydrogen bonds and hydrophobic effects, that maintain the protein's native three-dimensional structure. While the covalent peptide bonds remain intact, the protein loses its functional fold and activity.

219. (A) Hydrophobic interactions between nonpolar patches on subunit surfaces
The association of multiple polypeptide subunits into a quaternary structure is driven by the same forces that stabilize the tertiary structure. In most cases, the primary driving force is the hydrophobic effect, where nonpolar patches on the surfaces of the subunits are buried at the interface to minimize contact with water. Hydrogen bonds and ionic interactions also contribute to assembly.

220. (B) I and III
The physical properties of proteins are used for their characterization. Proteins are least soluble at their isoelectric point because the lack of a net charge reduces electrostatic repulsion. UV absorbance at 280 nm is a standard method for quantification, as it is proportional to the concentration of aromatic residues. High salt concentrations typically decrease solubility through the salting out effect.

221. (D) The resulting derivatives are highly fluorescent, allowing detection at low concentrations.
Dansyl chloride is a valuable reagent for identifying the N-terminal amino acid of a protein. It reacts with the primary amino group to form a stable derivative that remains intact during subsequent acid hydrolysis of the polypeptide. The main advantage of this method is the intense fluorescence of the dansyl-amino acid, which allows for very high sensitivity and detection.

222. (C) Base stacking interactions are disrupted, increasing the molar extinction coefficient.
The hyperchromic shift is the increase in ultraviolet light absorption that occurs when DNA denatures. In the double-stranded state, the aromatic bases are stacked, which reduces their molar extinction coefficient through electronic interactions. When the DNA melts and the strands separate, this stacking is lost, allowing the bases to absorb light more effectively. This shift monitors denaturation.

223. (B) The proportion of unique, moderately repetitive, and highly repetitive sequences
Cot curve analysis provides a window into the overall organization of a genome. By measuring the rate of DNA reassociation, researchers can determine the proportions of unique, moderately repetitive, and highly repetitive sequences in a sample. This information is critical for understanding the complexity of different genomes and has been used to study the structure of many biological genomes.

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224. (B) Phosphodiester bond
The primary structure of DNA and RNA consists of a linear chain of nucleotides. These units are joined together by covalent 3',5'-phosphodiester bonds, which connect the phosphate group of one nucleotide to the sugar of the next. This strong chemical linkage forms the permanent backbone of the nucleic acid molecule, while hydrogen bonds between the bases are responsible for structure.

is approximately 3.4 Angstroms. This precise spacing is maintained by van der Waals forces and hydrophobic interactions, contributing to the overall stability and regular geometry of DNA.

169. (B) They protect the mRNA from degradation and facilitate translation initiation.
Eukaryotic messenger RNA undergoes several modifications before it can be translated. A 7-methylguanosine cap is added to the 5' end, and a poly(A) tail is added to the 3' end. These structures are essential for protecting the mRNA from enzymatic degradation by exonucleases. They also play a critical role in the export of mRNA from the nucleus and translation.

170. (A) P-3, Q-1, R-2, S-4
Several terms are fundamental to biochemistry. A hyperchromic shift is the increase in UV absorbance seen during DNA denaturation. Cot curves are used to study the reassociation kinetics of DNA. A zwitterion is a molecule that carries both positive and negative charges but has no net charge. A motif is a recognizable folding pattern formed by secondary structure elements.

171. (A) Proline
Although proline is often grouped with the amino acids, it is technically an imino acid. This is because its side chain is bonded back to the nitrogen of the amino group, forming a five-membered pyrrolidine ring. This secondary amine structure significantly affects the flexibility of the polypeptide backbone and prevents proline from participating in standard helical hydrogen bonding.

172. (C) By lowering the activation energy required for the transition state
Enzymes are biological catalysts that significantly increase the rate of chemical reactions. They achieve this by providing an alternative reaction pathway with a lower activation energy for the transition state. Importantly, enzymes do not change the overall free energy of the reaction or the position of the equilibrium; they simply allow the system to reach equilibrium much faster.

173. (D) Van der Waals repulsive forces
As a protein folds, many different atoms come into close proximity. While attractive forces like hydrogen bonds and hydrophobic effects pull the chain together, van der Waals repulsive forces prevent atoms from overlapping. These repulsive forces occur when the electron clouds of two atoms get too close, providing the necessary resistance to maintain proper distances between protein components.

174. (C) Chain termination by dideoxynucleotides during DNA synthesis
The Sanger sequencing method, also known as the dideoxy method, is a cornerstone of genomic research. It exploits the ability of DNA polymerase to synthesize a complementary strand while using modified nucleotides that act as chain terminators. By including a small amount of these dideoxynucleotides in the reaction, synthesis is stopped at specific bases, producing fragments that reveal sequence.

175. (A) I and II
Restriction mapping is a technique used to determine the relative locations of specific DNA sequences recognized by enzymes. This process involves digesting a DNA sample with one or more restriction endonucleases and then separating the resulting fragments by size using gel electrophoresis. By comparing the patterns of fragments produced by different enzymes, researchers can construct a map of restriction sites.

176. (D) High levels of carbon dioxide in actively metabolizing tissues
The T-state of hemoglobin is the low-affinity conformation that favors the release of oxygen. This state is promoted by several physiological conditions found in actively metabolizing tissues. High concentrations of carbon dioxide and protons, along with the presence of 2,3-bisphosphoglycerate, stabilize the T-state. These factors collectively ensure that oxygen is unloaded from hemoglobin to meet high metabolic demands efficiently.

177. (A) Masking of the electrostatic charges on the protein, reducing aggregation
At low concentrations, the addition of salt can increase the solubility of a protein in water. The salt ions associate with the charged groups on the protein's surface, which helps to shield the electrostatic attractions between different protein molecules. By reducing these attractive forces, the salt prevents the proteins from

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are denser than adenine and thymine pairs, DNA with a higher G-C content will migrate to a denser part of the gradient, allowing for separation based on composition.

235. (D) I, II and III
RNA is a versatile molecule that can fold into complex three-dimensional structures. While it is single-stranded, it often contains internal regions of base-pairing, including non-standard G-U pairs. The presence of a 2'-hydroxyl group on the ribose sugar makes RNA more susceptible to chemical hydrolysis compared to DNA, contributing to its lower inherent stability in various biological environments.

236. (B) cAMP
Cyclic adenosine monophosphate is a derivative of ATP that serves as a critical secondary messenger in many cellular signaling pathways. It is produced by the enzyme adenylyl cyclase in response to various extracellular signals, such as hormones. By activating specific kinases and other targets, cAMP translates these signals into a wide range of biological responses within the cellular environment.

237. (D) Hydrogen bonds between specific base pairs
The double-helical structure of DNA is stabilized by specific interactions between the two strands. Hydrogen bonds form between the complementary nitrogenous bases on opposite strands, with adenine pairing with thymine and guanine pairing with cytosine. These bonds, along with base stacking, provide the necessary stability to hold the two strands together while still allowing them to be separated.

238. (B) 10.5
The B-form of the DNA double helix is the most common structural conformation found in biological systems. In this form, the helix makes one complete turn approximately every 36 Angstroms. This turn encompasses about 10.5 base pairs, resulting in a rotation of roughly 34 degrees per base pair. This geometry is essential for the proper functioning of DNA during biological processes.

239. (B) Symmetric cleavage exactly in the center of the recognition sequence
Restriction endonucleases can cut DNA in different ways. Some enzymes make staggered cuts that leave overhanging single-stranded ends, while others cut both strands at the same position directly across from each other. This symmetric cleavage in the center of the recognition sequence produces "blunt ends," which have no overhangs. While blunt ends are less efficient for cloning than sticky ends.

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240. (A) $III \backslash to I \backslash to II \backslash to IV$
Recombinant DNA cloning involves a logical sequence of laboratory procedures. First, both the vector and the DNA insert must be digested with the same restriction enzymes to create compatible ends. Next, these fragments are joined by DNA ligase. The resulting recombinant DNA is then introduced into host cells through transformation, followed by selection to identify the successful recombinant clones.

241. (A) To facilitate correct protein folding and prevent aggregation
The primary biological role of chaperone proteins is to ensure that other proteins fold correctly into their functional three-dimensional shapes. They achieve this by binding to unfolded or partially folded polypeptide chains, which prevents them from aggregating or forming incorrect interactions. By providing a protected environment, chaperones help the cell maintain a population of functional proteins and prevent misfolding.

242. (C) Cyanogen bromide (CNBr)
Cyanogen bromide is a chemical reagent used in the primary structure determination of proteins. It is highly selective, cleaving the polypeptide chain specifically on the carboxyl side of methionine residues. This reaction converts the methionine into a C-terminal homoserine lactone. This method is used to break large proteins into smaller fragments that can be more easily sequenced by degradation.

243. (B) Decreases hemoglobin's affinity for oxygen to facilitate unloading in tissues
When humans move to high altitudes, the body adapts to the lower oxygen levels by increasing the production of 2,3-bisphosphoglycerate in red blood cells. 2,3-BPG binds to hemoglobin and decreases its affinity for oxygen. This change facilitates the unloading of oxygen from hemoglobin into the tissues, ensuring that the cells receive an adequate supply despite lower availability.

225. (A) Both A and R are true and R is the correct explanation of A.
Sickle cell anemia is a genetic disorder caused by a single point mutation in the gene encoding the beta-globin chain of hemoglobin. This mutation results in the substitution of a hydrophilic glutamate residue with a hydrophobic valine at the sixth position. This change creates a hydrophobic patch that causes deoxygenated hemoglobin molecules to aggregate into long fibers, damaging cells.

226. (C) The allowed rotational angles around the N-Cα and Cα-C bonds
The conformation of the polypeptide backbone is defined by the rotation around two bonds: the N-C alpha bond and the C alpha-C bond. These rotations are represented by the phi and psi angles, respectively. A Ramachandran plot identifies the combinations of these angles that are sterically allowed, providing a visual map of the possible secondary structures a protein adopts.

227. (A) Bind calcium ions or specific DNA sequences
The helix-loop-helix is a common protein motif that consists of two alpha-helices joined by a flexible loop. This structure is frequently involved in mediating specific interactions with other molecules. For example, some helix-loop-helix motifs are specialized for binding divalent calcium ions, while others are essential for the sequence-specific binding of regulatory proteins to the major groove of DNA.

228. (D) A single polypeptide chain can contain multiple independently folding domains.
A protein domain is a compact and stable part of a polypeptide chain that can fold independently into a functional structure. Large proteins are often composed of several domains, which may be connected by flexible linker regions. A single polypeptide can contain multiple domains, each with its own specific biological role, such as binding a substrate or providing a structural anchor.

229. (B) Usually results in the loss of biological activity
Protein denaturation is the loss of the native three-dimensional structure due to environmental changes like heat or pH. This process disrupts the non-covalent interactions that maintain the functional fold, almost always resulting in the loss of biological activity. Although the primary sequence remains unchanged, the unfolded protein is usually less soluble and more prone to aggregation in aqueous solutions.

230. (A) P-2, Q-4, R-3, S-1
Analytical methods separate proteins based on different physical properties. SDS-PAGE determines the molecular weight of denatured subunits, while isoelectric focusing measures the pI. Gel filtration chromatography separates molecules by their native size or Stokes radius. Analytical ultracentrifugation is used to determine the sedimentation coefficient, which reflects both the mass and the shape of the protein in solvent.

231. (D) Salt bridges (ionic interactions)
Ionic interactions, also known as salt bridges, form between oppositely charged amino acid side chains. These interactions are highly sensitive to changes in the surrounding pH because the protonation state of the acidic and basic groups depends on the concentration of hydrogen ions. When the pH shifts, these groups can lose their charge, leading to the disruption of stabilizing forces.

232. (A) Histidine
The side chain of histidine contains an imidazole ring with a pK_a value of approximately 6.0. This is closer to physiological pH than the pK_a values of the other basic or acidic amino acids. Because its pK_a is near neutrality, histidine can easily switch between protonated and deprotonated forms, making it a versatile residue for acid-base catalysis in enzymes.

233. (B) The alpha-carboxyl group and the side-chain carboxyl group
Aspartate is an acidic amino acid with an ionizable side chain carboxyl group. The isoelectric point is the pH at which the molecule has a net charge of zero. For acidic amino acids, this point is calculated by taking the average of the two lowest pK_a values, which are the pK_a of the α-carboxyl group and the side-chain group.

234. (B) G-C content
In equilibrium density gradient ultracentrifugation, DNA molecules separate based on their buoyant density. This density is primarily determined by the base composition of the DNA. Because guanine and cytosine pairs

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to the presence of the aromatic amino acids tryptophan and tyrosine. These residues contain conjugated ring systems that absorb light in the UV range. Tryptophan is the most significant contributor, and this absorbance is widely used in biochemistry for protein quantification.

254. (C) Spontaneous if the primary sequence is intact and appropriate conditions are restored
The process of renaturation is the return of a denatured protein to its original functional native structure. As demonstrated by Anfinsen, this process can be spontaneous if the primary sequence is intact and the denaturing agents are removed under the correct conditions. This shows that the final three-dimensional fold is determined by the sequence of amino acids, representing the minimum.

255. (B) II and III
Collagen is a fibrous protein that provides structural support to tissues. It is characterized by a triple-helical structure where three polypeptide chains are wound around each other. The primary sequence of these chains is highly repetitive, with glycine occurring at every third position to allow for tight packing. Bulky amino acids are not typically found in this structural arrangement.

256. (D) 3',5'-Phosphodiester bond
The individual nucleotides in a DNA or RNA strand are connected by covalent 3',5'-phosphodiester bonds. This bond forms between the 3'-hydroxyl group of one sugar and the 5'-phosphate group of the next sugar. These strong chemical linkages create the continuous sugar-phosphate backbone of the nucleic acid, ensuring structural integrity during cellular processes like replication and transcription.

257. (A) Melting temperature (T_m)
The melting temperature is a key physical property used to describe the thermal stability of double-stranded DNA. It is defined as the temperature at which 50% of the helical structure has been lost, meaning half of the DNA has denatured into single strands. The T_m depends on the base composition and length of the DNA, as well as ionic strength.

258. (C) They cleave at precise locations within a specific recognition sequence.
Type II restriction enzymes are extremely valuable tools in molecular biology because of their high specificity. Unlike other types of restriction enzymes, they recognize a specific DNA sequence and cut the strands at precise locations within or very close to that sequence. This allows researchers to reliably fragment DNA into predictable pieces, which is essential for gene cloning and mapping.

259. (C) Three
When a linear DNA molecule is cut by a restriction enzyme, the number of resulting fragments is always one more than the number of restriction sites. If a linear molecule has two recognition sites for the enzyme BamHI, the digestion will break the chain at two locations, dividing the original molecule into exactly three smaller DNA fragments of varying lengths.

260. (A) $II\backslash toIII\backslash toI\backslash toIV$
The Maxam-Gilbert method for sequencing DNA involves a specific series of chemical steps. The process starts with end-labeling the DNA fragment, followed by base-specific chemical modification. Next, the DNA is cleaved at the modified bases. Finally, the resulting collection of fragments is separated by size using high-resolution polyacrylamide gel electrophoresis, allowing the sequence to be read from the bands.

261. (B) Shorter and wider with tilted base pairs
A-DNA is a structural alternative to the more common B-form of the DNA double helix. Compared to B-DNA, the A-form is shorter and wider, with a more compressed helical structure. The base pairs are tilted relative to the helix axis rather than being perpendicular to it. This conformation is typically adopted by DNA-RNA hybrids and double-stranded RNA molecules.

NODIA

262. (C) Beta-mercaptoethanol
To completely denature a protein that contains disulfide bonds, a reducing agent must be used. Beta-mercaptoethanol is a common chemical reagent employed for this purpose in the laboratory. It works by reducing the covalent disulfide bridges back to individual sulfhydryl groups. This process, often performed in the presence of a denaturant like urea, allows the polypeptide to unfold completely.

P. Absolute specificity
Q. Group specificity
R. Stereospecificity
S. Linkage specificity

List II: (Example)

1. Hexokinase acting on various six-carbon sugars
2. Urease catalyzing the hydrolysis of urea only
3. Alpha-amylase breaking down alpha-1,4-glycosidic bonds
4. L-amino acid oxidase acting only on L-amino acids

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

2006

31. What defines a holoenzyme?
(A) An enzyme completely lacking its necessary cofactor
(B) A denatured enzyme incapable of catalysis
(C) An inactive precursor requiring proteolytic cleavage
(D) A catalytically active complex of a protein and its coenzyme/cofactor

2009

32. The protein portion of an enzyme, exclusive of any organic or inorganic cofactors, is termed:
(A) Holoenzyme
(B) Zymogen
(C) Apoenzyme
(D) Co-substrate

2021

33. A tightly or covalently bound non-protein structural component required for enzyme function is called a:
(A) Co-substrate
(B) Prosthetic group
(C) Zymogen
(D) Activator ion

2018

34. Which of the following differentiates a co-substrate from a prosthetic group?
(A) Co-substrates are tightly bound to the enzyme active site
(B) Co-substrates are strictly inorganic metal ions
(C) Co-substrates do not participate directly in the catalytic mechanism
(D) Co-substrates loosely bind and dissociate from the enzyme during the reaction

2023

35. Identify the correct relationship between enzyme components.
(A) Holoenzyme - Coenzyme = Apoenzyme
(B) Apoenzyme + Prosthetic group = Zymogen
(C) Holoenzyme + Co-substrate = Apoenzyme
(D) Apoenzyme - Cofactor = Holoenzyme

2004

36. Which statement concerning prosthetic groups is INCORRECT?
(A) They are permanently associated with their respective enzymes
(B) They typically undergo chemical changes during catalysis and are regenerated in situ
(C) They freely diffuse through the cytoplasm between distinct reactions
(D) Heme in cytochrome c is a classic example of a prosthetic group

2009

37. Flavin adenine dinucleotide (FAD) is commonly associated with enzymes as a:
(A) Tightly bound prosthetic group
(B) Transient co-substrate
(C) Regulatory allosteric inhibitor
(D) Simple metal ion cofactor

2019

38. NAD+ participates in dehydrogenase reactions predominantly as a:
(A) Prosthetic group
(B) Competitive inhibitor
(C) Zymogen activator
(D) Co-substrate

2021

39. Which of the following is most likely to act as a co-substrate in metabolic group transfer reactions?
(A) Pyridoxal phosphate (PLP)
(B) Coenzyme A (CoA)
(C) FMN
(D) Zinc ion

2001

40. Select the correct sequence of steps representing the IUBMB classification of enzymes.
(A) Serial number → Class → Subclass → Sub-subclass
(B) Subclass → Class → Sub-subclass → Serial number
(C) Class → Subclass → Sub-subclass → Serial number
(D) Class → Sub-subclass → Subclass → Serial number

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for one complete turn of the helix, which is approximately 3.6. This geometry results in a stable and compact.

273. (A) Left-handed triple helix
Collagen is the primary structural protein of the body and is distinguished by its unique architecture. It is composed of three separate polypeptide chains that are wrapped around each other to form a left-handed triple helix. This structure is stabilized by hydrogen bonds between the chains and is made possible by the high content of glycine, proline, and hydroxyproline.

274. (C) The surface layer of amphipathic phospholipids and apolipoproteins
Lipoproteins are complex particles that transport hydrophobic lipids through the aqueous blood plasma. Their solubility is achieved by their structure, which features an internal core of triglycerides and cholesterol esters surrounded by a surface layer of amphipathic molecules. This surface contains phospholipids and apolipoproteins, whose polar regions interact with the surrounding water while their nonpolar regions face the core.

275. (D) I, II and III
Hemoglobin is a complex, multimeric protein that is essential for oxygen transport. It is a tetramer composed of two alpha and two beta subunits, which allow for the cooperative binding of oxygen that results in a sigmoidal saturation curve. Additionally, hemoglobin's affinity for oxygen is sensitive to pH changes, a phenomenon known as the Bohr effect, where lower pH.

276. (D) Uracil
The nitrogenous bases that make up the genetic code are specific to each type of nucleic acid. While adenine, cytosine, and guanine are common to both, thymine is the base found in DNA, whereas uracil is found in RNA. Therefore, uracil is not a standard component of cellular DNA, although it can occasionally appear as a result of deamination.

277. (B) The hyperchromic shift is 50% complete
The melting temperature is a fundamental property of a DNA double helix. It is experimentally defined as the midpoint of the hyperchromic shift, which is the point at which 50% of the DNA has transitioned from a double-stranded to a single-stranded state. The T_m provides a clear indicator of the thermal stability and base composition of a DNA sample.

278. (C) SmaI
Restriction endonucleases differ in the type of DNA ends they produce after cleavage. While enzymes like EcoRI and BamHI create staggered cuts with single-stranded overhangs, the enzyme SmaI recognizes the sequence CCCGGG and cuts both strands exactly in the center. This results in the production of blunt ends, which lack any single-stranded overhangs and have different requirements for ligation.

279. (D) Provides a wide surface for sequence-specific recognition by DNA-binding proteins
The B-form of the DNA double helix features two distinct grooves. The major groove is larger and more accessible than the minor groove, exposing a wider surface area of the nitrogenous bases to the surrounding environment. This accessibility makes it the primary site for the sequence-specific binding of regulatory proteins, such as transcription factors, which recognize chemical patterns.

280. (A) P-3, Q-2, R-4, S-1
Nucleic acids are built from a hierarchy of components. A purine is a double-ring nitrogenous base, while a pyrimidine has a single ring. A nucleoside is formed by the combination of a nitrogenous base and a sugar. When one or more phosphate groups are added to a nucleoside, the resulting molecule is a nucleotide, the fundamental unit.

281. (B) The binding of one oxygen molecule increases the affinity of the remaining vacant sites for oxygen.
In the context of hemoglobin, cooperativity refers to functional communication between its four subunits. When one oxygen molecule binds to a subunit, it induces a conformational change that increases the affinity of the remaining vacant sites for oxygen. This positive cooperativity allows hemoglobin to bind oxygen very efficiently in the lungs where its partial pressure is high, yielding sigmoidal.

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(A) A metalloenzyme
(B) A catalytic antibody
(C) A regulatory lipid
(D) A ribozyme

2004

10. Consider the following statements about biocatalysts:
I. Abzymes are typically generated using transition-state analogs.
II. All ribozymes require a protein component to exhibit catalysis.
III. Enzymes accelerate reaction rates by lowering activation energy.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2004

11. What represents the actual change in Gibbs free energy (ΔG) when a biochemical system reaches chemical equilibrium?
(A) It is highly positive in value
(B) It is perfectly equal to zero
(C) It favors the reverse reaction
(D) It depends on concentration

2021

12. In enzyme thermodynamics, a negative ΔG indicates that the reaction is:
(A) Spontaneous and endergonic
(B) Spontaneous and exergonic
(C) Non-spontaneous and exergonic
(D) Non-spontaneous and endergonic

2021

13. Which thermodynamic parameter determines the direction of an enzyme-catalyzed reaction?
(A) Gibbs free energy change
(B) Activation energy
(C) The binding energy of the substrate
(D) The turnover number

2002

14. What occurs to the reaction equilibrium when an enzyme is added to a system?
(A) The equilibrium shifts towards the products
(B) The equilibrium shifts towards the reactants
(C) The equilibrium point remains completely unchanged
(D) The equilibrium constant ($K_{\{eq\}}$) decreases

2009

15. The relationship between standard free energy change and the equilibrium constant is expressed by which equation?
(A) $\Delta G = \Delta H - T\Delta S$
(B) $v = \dfrac{V_{\max}[S]}{K_m + [S]}$
(C) $\Delta G^{\circ} = RT\log K_{eq}$
(D) $\Delta G^{\circ} = -RT\ln K_{eq}$

2017

16. Identify the correct statement regarding enzyme catalysis and thermodynamics.
(A) Enzymes increase the energy difference between reactants and products
(B) Enzymes decrease the free energy of the products
(C) Enzymes provide an alternative reaction pathway with lower activation energy
(D) Enzymes supply thermal energy to drive reactions

2003

17. Which component contributes to the binding energy (ΔG_B) released upon enzyme-substrate complex formation?
(A) Covalent bond formation only
(B) Weak noncovalent interactions between enzyme and substrate
(C) The kinetic energy of the surrounding solvent
(D) The breakdown of the transition state

2012

18. How does an enzyme facilitate a reaction with a highly unstable transition state?
(A) By permanently binding the transition state molecule
(B) By increasing the total enthalpy of the system
(C) By modifying the overall standard free energy change
(D) By lowering the free energy of the transition state

2017

19. An endergonic biochemical reaction can be driven forward in vivo by which mechanism?
(A) Coupling it with a highly exergonic reaction, such as ATP hydrolysis
(B) Increasing the concentration of the products
(C) Lowering the environmental temperature significantly
(D) Removing the corresponding enzyme from the medium

NODIA

291. (A) A-DNA has a right-handed helix, whereas Z-DNA has a left-handed helix.
A-DNA and Z-DNA represent two different structural alternatives to the common B-form of the double helix. The most fundamental difference between them is the direction of the helical rotation. A-DNA is a right-handed helix, similar to B-DNA but with a more compressed shape. In contrast, Z-DNA is a left-handed helix that features a zig-zag arrangement of backbone.

292. (D) It binds via electrostatic interactions to the central cavity of the deoxygenated T-state.
2,3-iso-bisphosphoglycerate is a negatively charged allosteric regulator that controls hemoglobin's oxygen affinity. It binds to a specific site within the central cavity of the hemoglobin tetramer, which is lined with positively charged amino acids. This binding occurs only in the deoxygenated T-state, where the cavity is large enough to accommodate the molecule. This interaction stabilizes T-state effectively.

293. (B) It folds into a compact L-shape maintained by complex base-pairing and stacking.
Although the secondary structure of tRNA is traditionally represented as a cloverleaf, its functional three-dimensional shape is a compact L-shape. This tertiary fold is achieved through complex internal base-pairing and stacking interactions that involve various loops and stems. The L-shaped structure is essential for the tRNA to fit into the different sites of the ribosome during translation.

294. (C) The sedimentation coefficient, which correlates with molecular weight and shape
Analytical ultracentrifugation is a classic technique used in biochemistry to study the physical properties of macromolecules in solution. By monitoring the sedimentation of a molecule under high centrifugal forces, researchers can determine its sedimentation coefficient. This value provides information about the molecular weight, size, and three-dimensional shape of the particle, as well as the purity and homogeneity.

295. (A) I, II, III, IV and V
Recombinant DNA technology relies on a set of core tools and procedures to clone a specific DNA fragment. This includes Type II restriction enzymes for precise cutting, DNA ligase for joining fragments, and a plasmid vector for carrying the insert. Additionally, competent host cells and a transformation process are needed to multiply the recombinant DNA and select clones.

296. (A) The largest molecules, because they are excluded from the pores of the beads and pass rapidly through the column.
Gel filtration chromatography, also known as size-exclusion chromatography, separates molecules based on their size and shape. The column is packed with porous beads. Smaller molecules can enter these pores and are delayed as they move through the column. In contrast, larger molecules are excluded from the pores and travel only through the space between beads, resulting in earlier elution.

297. (B) It facilitates the polymerization of IgA into dimers and IgM into pentamers.
The joining chain is a specialized polypeptide found in some classes of immunoglobulins. Its primary role is to facilitate the assembly of multiple antibody monomers into larger polymeric structures. Specifically, the J chain is required for the formation of dimeric IgA and pentameric IgM. This polymerization is important for increasing the valency and biological effectiveness of these antibodies.

298. (B) They are often produced by post-translational enzymatic modification of standard amino acids within a polypeptide.
Non-standard amino acids are not part of the basic set of twenty residues used during ribosomal translation. Instead, they are usually produced within the cell by the enzymatic modification of standard amino acids after they have been incorporated into a polypeptide chain. These post-translational modifications are essential for diversifying the chemical and functional properties of proteins in the cell.

299. (B) Neoschizomers
Restriction enzymes are categorized based on their recognition and cleavage sites. Isoschizomers are enzymes that recognize and cut at the same DNA sequence in the same way. In contrast, neoschizomers are a subset of isoschizomers that recognize the same specific DNA sequence but cleave it at different positions. These variations are useful in molecular biology for creating specific ends.

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263. (D) Peptide bonds
The primary structure of a protein is defined by the linear sequence of amino acids in the polypeptide chain. This level of organization is maintained exclusively by covalent peptide bonds, which form the backbone of the molecule. While other interactions like hydrogen bonds and hydrophobic effects are critical for higher-order folding, the integrity of the primary sequence depends on these bonds.

264. (A) Hydrophobicity
Reverse-phase high-performance liquid chromatography is a technique used to separate and purify proteins based on their relative hydrophobicity. The stationary phase in the column consists of nonpolar molecules, which interact with the hydrophobic regions of the proteins. Proteins are then eluted using a gradient of organic solvent, with the most hydrophobic proteins eluting last as they have strongest interactions.

265. (A) Both A and R are true and R is the correct explanation of A.
The Sanger sequencing method relies on the use of modified nucleotides called ddNTPs to terminate DNA synthesis. These molecules lack the 3'-hydroxyl group on the sugar, which is required by DNA polymerase to form a phosphodiester bond with the next incoming nucleotide. Once a ddNTP is incorporated, no further nucleotides can be added, resulting in a stable termination.

266. (B) Affinity chromatography
Affinity chromatography is a highly specific method for purifying proteins based on their biological function. It exploits the unique ability of a protein to bind reversibly to a specific ligand that is immobilized on the chromatography matrix. By passing a mixture over the column, the target protein is selectively captured while other proteins are washed away, allowing for high-level purification.

267. (A) It denatures proteins and confers a uniform negative charge-to-mass ratio.
Sodium dodecyl sulfate is an anionic detergent used in protein electrophoresis. It serves two main functions: it denatures the proteins by disrupting non-covalent interactions and it binds to the polypeptide chain to confer a uniform negative charge-to-mass ratio. This ensures that the proteins are separated in the gel based strictly on their molecular weight rather than native charge.

268. (C) Glycine
Ultraviolet light absorption in proteins at 280 nanometers is primarily due to the aromatic side chains of tryptophan and tyrosine. Amino acids that lack these aromatic rings, such as glycine, do not exhibit significant absorbance in this region of the spectrum. Glycine, with its simple hydrogen side chain, is effectively transparent at 280 nm, making it non-contributory to quantification.

269. (D) A short palindromic sequence
Restriction endonucleases are specialized enzymes that recognize and cut DNA at specific nucleotide sequences. For most Type II enzymes, these recognition sites are short, palindromic sequences that are typically four to six base pairs in length. In a palindrome, the sequence is the same on both strands when read in the 5' to 3' direction, allowing for symmetric cleavage.

NODIA

270. (A) P-3, Q-1, R-2, S-4
Protein purification exploits various physical and chemical differences between molecules. Ion-exchange chromatography separates proteins by their net charge, while gel filtration uses size and shape. Affinity chromatography relies on specific binding to a ligand. Salting out uses high salt concentrations to reduce solubility. These diverse techniques are used in combination to achieve high levels of purity for research.

271. (B) Toward the acidic end until it reaches pH 6.5 and then stop
In an isoelectric focusing experiment, proteins move through a pH gradient under the influence of an electric field. If a protein is placed in an environment where the pH is higher than its pI, it will carry a net negative charge and migrate toward the positive electrode (the acidic end). The migration continues until the protein reaches its pI.

272. (B) 3.6
The alpha-helix is a fundamental secondary structure element in proteins. It is characterized by a right-handed spiral where the polypeptide backbone is stabilized by internal hydrogen bonds. A defining feature of this structure is the number of amino acid residues required

CHAPTER 04
Enzymes

2022

1. Which of the following defines a ribozyme in biological systems?
(A) A lipid molecule exhibiting catalytic turnover
(B) An RNA molecule capable of acting as an enzyme
(C) A protein that degrades foreign nucleic acids
(D) An engineered antibody with catalytic properties

2009

2. What is the primary evolutionary advantage of abzymes over natural enzymes?
(A) They are found naturally in all prokaryotes
(B) They utilize RNA instead of amino acids for catalysis
(C) They function optimally at extreme temperatures without unfolding
(D) They can be engineered to catalyze reactions for which no natural enzyme exists

2001

3. Which statement accurately describes the catalytic nature of biocatalysts?
(A) They increase reaction rates without undergoing permanent chemical change
(B) They alter the equilibrium constant of a reaction
(C) They remain consumed after completing a chemical reaction
(D) They shift the direction of a non-spontaneous reaction

2002

4. How does an enzyme affect the thermodynamics of a biochemical reaction?
(A) It decreases the overall Gibbs free energy change
(B) It increases the enthalpy of the reaction products
(C) It leaves the overall Gibbs free energy change unaffected
(D) It makes an endergonic reaction exergonic

2003

5. The discovery of catalytic RNA challenged which traditional biological concept?
(A) Enzymes are exclusively proteinaceous in nature
(B) DNA is the sole genetic material in eukaryotes
(C) Lipids form the structural components of membranes
(D) Carbohydrates are necessary for signal transduction

2007

6. Identify the INCORRECT statement regarding catalytic antibodies (abzymes).
(A) They are elicited by using transition-state analogs
(B) They bind their substrates with high specificity
(C) They demonstrate typical Michaelis-Menten kinetics
(D) They are synthesized by ribosomes for metabolism

2015

7. What is the biological role of the naturally occurring ribozyme RNase P?
(A) It synthesizes ribosomal RNA components
(B) It cleaves precursor tRNA to generate mature tRNA
(C) It acts as a ligase during genomic DNA replication
(D) It degrades incorrectly folded structural proteins

2019

8. Which factor most heavily influenced the early evolution of ribozymes?
(A) The availability of complex tertiary protein structures
(B) The necessity to strictly regulate human metabolic pathways
(C) The RNA world hypothesis where RNA served as both genetic and catalytic material
(D) The presence of synthetic transition-state analogs

2016

9. Peptidyl transferase, a key catalytic component of the ribosome, is classified as which type of molecule?

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282. (B) Produce carbon dioxide and lactic acid, lowering the local pH and promoting oxygen release
The Bohr effect is a physiological adaptation that improves oxygen delivery to tissues with high metabolic activity. As these tissues work, they produce carbon dioxide and lactic acid, which increases the concentration of protons and lowers the local pH. These conditions stabilize the deoxygenated state of hemoglobin, facilitating the release of oxygen where it is most needed by tissues.

283. (A) It cannot be synthesized by the organism at a rate commensurate with its demand, and must be obtained from the diet.
Essential amino acids are a subset of the building blocks of proteins that cannot be synthesized by the organism from metabolic precursors. Because the body lacks the enzymatic pathways to produce these molecules endogenously, they must be obtained through dietary sources. Failing to consume enough of these amino acids will impair protein synthesis and lead to significant nutritional deficiencies.

284. (C) Desmosine
Elastin is the protein responsible for the elasticity of connective tissues like the skin and arteries. Its structure is characterized by extensive cross-linking between the polypeptide chains. The most distinctive of these cross-links is desmosine, which is a non-standard amino acid formed from the condensation of four lysine side chains. These covalent bonds create a resilient, rubbery structural network.

285. (A) Both A and R are true and R is the correct explanation of A.
Chaperones are essential proteins that assist in the folding process by preventing aggregation and incorrect interactions. However, they do not provide the information for the final structure. As stated in Anfinsen's principle, the native tertiary structure of a protein is determined solely by its primary sequence, which represents the global minimum. Chaperones simply help the protein reach state.

286. (C) Disulfide bonds
Extracellular proteins are often exposed to harsh environments, including changes in pH and temperature. To maintain their structural integrity under these conditions, many of these proteins are stabilized by covalent disulfide bonds between cysteine residues. These strong chemical cross-links provide significant resistance to denaturation and help to hold the polypeptide chain in its functional three-dimensional fold securely.

287. (C) Akabori hydrazinolysis
Akabori hydrazinolysis is a chemical method used to identify the amino acid at the C-terminal end of a protein. The polypeptide is treated with anhydrous hydrazine at high temperatures, which cleaves all peptide bonds and converts the internal amino acids into amino acid hydrazides. Only the C-terminal amino acid is released as a free amino acid, allowing identification.

NODIA

288. (D) The steric hindrance (clashing) between atoms of the polypeptide backbone and side chains
A Ramachandran plot defines the allowed conformations of the protein backbone by examining the ϕ and ψ angles. The disallowed regions on the plot correspond to combinations of these angles that are physically impossible because they would cause atoms to overlap. This steric hindrance, or clashing, between the atoms of the backbone and the side chains restricts folding.

289. (A) Two right-handed alpha-helices wrapped around each other in a left-handed coiled-coil
Alpha-keratin is the structural protein of hair and wool. Its fundamental unit is an alpha-helix, which associates with other helices to form more complex structures. Specifically, two right-handed alpha-helices wrap around each other in a left-handed orientation to form a coiled-coil. This architecture is stabilized by extensive disulfide cross-linking, providing the mechanical strength and resilience characteristic of fibers.

290. (A) Only I
Thermal denaturation of DNA is the separation of the two strands of the double helix as the temperature increases. This process is reversible, as the strands can reassociate, or anneal, if they are cooled slowly. However, denaturation involves the disruption of hydrogen bonds rather than covalent phosphodiester bonds, and it results in an increase in ultraviolet light absorbance.

2021

20. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Enzymes do not alter the overall standard Gibbs free energy change (ΔG°) of a biochemical reaction.
Reason (R): Enzymes function solely by decreasing the activation energy barrier.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

21. Which thermodynamic variable measures the degree of randomness or disorder in a reacting biological system?
(A) Entropy (ΔS)
(B) Enthalpy (ΔH)
(C) Gibbs free energy (ΔG)
(D) Activation energy (E_a)

2002

22. According to transition state theory, what characterizes the transition state of a reaction?
(A) It is the most stable intermediate
(B) It can be easily isolated in an aqueous solution
(C) It possesses identical energy to the starting reactants
(D) It has the highest free energy along the reaction coordinate

2007

23. What describes the mathematical relationship between reaction rate and activation energy?
(A) The rate is directly proportional to activation energy
(B) The rate is inversely and exponentially related to activation energy
(C) The rate remains unaffected by activation energy changes
(D) The rate linearly decreases with activation energy

2009

24. Which concept explains the energetic advantage of enzyme catalysis?
(A) The enzyme stabilizes the substrate more than the transition state
(B) The enzyme transfers thermal energy directly to the substrate
(C) The enzyme's active site is perfectly complementary to the transition state
(D) The enzyme increases the collision frequency of all molecules

2016

25. What happens to the energy barrier when the active site of an enzyme is complementary to the stable substrate rather than the transition state?
(A) The reaction rate increases dramatically
(B) The transition state is easily bypassed
(C) The enzyme forms a product immediately
(D) The activation energy barrier increases, impeding the reaction

2013

26. Which type of enzyme specificity involves acting on a specific structural geometry or spatial arrangement?
(A) Stereospecificity
(B) Absolute specificity
(C) Group specificity
(D) Linkage specificity

2010

27. Hexokinase phosphorylating different hexose sugars (glucose, fructose, mannose) exemplifies which type of specificity?
(A) Absolute specificity
(B) Group specificity
(C) Stereospecificity
(D) Optical specificity

2005

28. Identify the INCORRECT statement regarding the enzyme active site.
(A) It occupies a relatively small volume compared to the entire protein
(B) It binds substrates primarily through strong, permanent covalent bonds
(C) It is a three-dimensional cleft or crevice
(D) It determines the specificity of the catalytic reaction

2012

29. Urease acts strictly upon urea and no other closely related compounds. This is an example of:
(A) Absolute specificity
(B) Group specificity
(C) Stereospecificity
(D) Broad specificity

2011

30. Match the specificity type in List I with its corresponding example in List II.
List I: (Specificity Type)

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300. (C) Primary structure
The most basic level of protein organization is the primary structure. This refers specifically to the unique, linear sequence of amino acids that are linked together by covalent peptide bonds in a polypeptide chain. The primary structure is determined by the information encoded in the gene and provides the foundation for all higher-order folding and the eventual biological function.

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2007

41. The Enzyme Commission (EC) number consists of how many digits?
(A) Two
(B) Three
(C) Four
(D) Five

2001

42. Under the IUBMB system, EC Class 3 corresponds to which category of enzymes?
(A) Hydrolases
(B) Oxidoreductases
(C) Transferases
(D) Lyases

2016

43. Which major enzyme class facilitates the transfer of a functional group (e.g., a methyl or phosphate group) from one molecule to another?
(A) Class 1: Oxidoreductases
(B) Class 2: Transferases
(C) Class 4: Lyases
(D) Class 5: Isomerases

2021

44. What does the first digit in an EC number indicate?
(A) The specific substrate acted upon
(B) The major class of the enzyme based on the reaction type
(C) The individual enzyme's serial number
(D) The cellular location of the enzyme

2009

45. In the EC number 1.1.1.1 (Alcohol dehydrogenase), the first "1" represents:
(A) Oxidoreductases
(B) Transferases
(C) Hydrolases
(D) Ligases

2022

46. An enzyme with the EC classification 6.x.x.x belongs to the class of:
(A) Isomerases
(B) Translocases
(C) Ligases
(D) Lyases

2024

47. Which enzyme class is responsible for the cleavage of C-C, C-O, or C-N bonds with the addition of water?
(A) Oxidoreductases
(B) Lyases
(C) Ligases
(D) Hydrolases

2018

48. Identify the correct statement regarding Translocases (EC Class 7).
(A) They catalyze the structural rearrangement of molecules
(B) They join two molecules utilizing ATP
(C) They catalyze the movement of ions or molecules across membranes
(D) They add groups to double bonds

2004

49. Which of the following is a classic example of an oxidoreductase?
(A) Hexokinase
(B) Lactate dehydrogenase
(C) Chymotrypsin
(D) Aldolase

2007

50. Arrange the following enzyme classes in ascending order according to their primary EC numbers (1 through 4):
I. Transferases
II. Lyases
III. Hydrolases
IV. Oxidoreductases
(A) IV, I, III, II
(B) I, II, III, IV
(C) IV, III, I, II
(D) II, IV, I, III

NODIA

2004

51. Kinases belong to which major class of enzymes?
(A) Transferases
(B) Hydrolases
(C) Ligases
(D) Isomerases

2024

52. What reaction type is catalyzed by enzymes classified as hydrolases?
(A) Addition of functional groups to double bonds
(B) Transfer of electrons between molecules
(C) Hydrolytic cleavage of specific chemical bonds
(D) Joining of two molecules with ATP hydrolysis

2021

53. Which characteristic differentiates lyases from hydrolases?
(A) Lyases cleave bonds by eliminating groups to form double bonds or rings without adding water

(D) $k_{\{cat\}}$

2016

96. What does $k_{\{cat\}}$ signify in enzyme kinetics?
(A) The specific binding affinity of the substrate
(B) The rate of enzyme degradation
(C) The number of substrate molecules converted to product per enzyme molecule per unit time, under saturating conditions
(D) The concentration of substrate required to reach $V_{\{\max\}}$

2001

97. The ratio $\frac{k_{cat}}{K_m}$ is a widely accepted measure of:
(A) Enzyme stability
(B) Catalytic efficiency and specificity
(C) Allosteric inhibition
(D) Substrate concentration

2003

98. When an enzyme operates with a $\frac{k_{cat}}{K_m}$ approaching 10^8 to $10^9 M^{-1}s^{-1}$, it is considered to have achieved:
(A) Absolute specificity
(B) Zero-order kinetic stability
(C) Complete irreversibility
(D) Catalytic perfection, limited only by diffusion

2022

99. Which constant dictates the rate of an enzymatic reaction when the substrate concentration is much lower than K_m?
(A) $\frac{k_{cat}}{K_m}$
(B) $V_{\{\max\}}$ only
(C) $k_{\{cat\}}$ only
(D) $\frac{1}{K_m}$

2023

100. Consider the following statements about catalytic efficiency:
I. Turnover number ($k_{\{cat\}}$) is calculated by dividing $V_{\{\max\}}$ by the total enzyme concentration.
II. A high K_m implies high catalytic efficiency.
III. $\frac{k_{cat}}{K_m}$ represents the apparent second-order rate constant at low substrate concentration.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2025

101. Reversible competitive inhibitors exert their effect primarily by binding to:
(A) The active site of the free enzyme
(B) The enzyme-substrate complex
(C) An allosteric site on the free enzyme
(D) The product

2007

102. In the presence of a competitive inhibitor, how are the kinetic parameters affected?
(A) $V_{\{\max\}}$ decreases, K_m remains unchanged
(B) Both $V_{\{\max\}}$ and K_m decrease
(C) Both $V_{\{\max\}}$ and apparent K_m increase
(D) $V_{\{\max\}}$ remains unchanged, apparent K_m increases

2015

103. On a Lineweaver-Burk plot, competitive inhibition is characterized by lines that:
(A) Intersect at the x-axis
(B) Intersect at the y-axis
(C) Are perfectly parallel
(D) Intersect in the third quadrant

2024

104. Non-competitive inhibition occurs when the inhibitor binds to:
(A) The active site, blocking substrate access completely
(B) Strictly to the product of the reaction
(C) Both the free enzyme and the enzyme-substrate complex with equal affinity
(D) Only the enzyme-substrate complex

2009

105. How does a pure non-competitive inhibitor alter Michaelis-Menten kinetics?
(A) It increases apparent K_m but leaves $V_{\{\max\}}$ unchanged
(B) It decreases both $V_{\{\max\}}$ and apparent K_m
(C) It increases both $V_{\{\max\}}$ and apparent K_m
(D) It decreases $V_{\{\max\}}$ but leaves K_m unchanged

2006

106. Uncompetitive inhibitors are unique because they bind exclusively to:
(A) The enzyme-substrate (ES) complex
(B) The free apoenzyme
(C) The unbound coenzyme
(D) The transition state intermediate

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2003

65. The induced-fit model explains which aspect of enzyme catalysis better than the lock-and-key model?
(A) The enzyme's ability to maintain rigid stability at high temperatures
(B) Broad group specificity and the prevention of non-productive reactions
(C) The requirement for continuous ATP consumption
(D) The absolute reliance on RNA instead of protein

2017

66. How does general acid-base catalysis operate to accelerate a biochemical reaction?
(A) By forming a transient covalent bond with the substrate
(B) By binding a metal ion to shield negative charges
(C) By strictly raising the local temperature of the active site
(D) By donating or accepting protons to stabilize the transition state

2025

67. Which amino acid side chain is most commonly involved in both general acid and general base catalysis at physiological pH?
(A) Histidine
(B) Leucine
(C) Phenylalanine
(D) Valine

2009

68. Covalent catalysis involves the formation of a transient covalent bond between the substrate and a(n):
(A) Non-reactive hydrophobic residue
(B) Electrophilic co-substrate in the medium
(C) Nucleophilic functional group on the enzyme
(D) Inert metal ion

2019

69. Which type of catalytic mechanism involves bringing two reactive groups close together in the correct spatial geometry?
(A) Proximity and orientation effects
(B) General acid-base catalysis
(C) Metal ion catalysis
(D) Electrostatic catalysis

2023

70. Consider the following statements about catalytic mechanisms:
I. Electrostatic catalysis stabilizes unstable charges on the transition state.
II. Covalent catalysis requires a nucleophile on the enzyme.
III. Proximity effects decrease the effective concentration of reactants.
IV. General acid-base catalysis relies exclusively on water molecules.
V. Histidine acts as a versatile general acid/base catalyst due to its pKa.
Which of the above statement(s) is/are correct?
(A) I, II and V
(B) I, III and IV
(C) II, III and V
(D) I, IV and V

2022

71. In metal ion catalysis, zinc ($Zn^{\{2+\}}$) often functions by:
(A) Donating electrons to form covalent bonds with the substrate
(B) Polarizing water to generate a highly nucleophilic hydroxide ion
(C) Modifying the primary sequence of the enzyme
(D) Acting as a general base to accept protons

NODIA

2005

72. Carbonic anhydrase requires which metal ion for its catalytic activity?
(A) Iron ($Fe^{\{2+\}}$)
(B) Copper ($Cu^{\{2+\}}$)
(C) Zinc ($Zn^{\{2+\}}$)
(D) Magnesium ($Mg^{\{2+\}}$)

2003

73. Which of the following defines a metalloenzyme?
(A) An enzyme that functions only in the presence of heavy metal inhibitors
(B) An enzyme that specifically degrades metallic compounds
(C) An enzyme loosely associated with metal ions that dissociate easily
(D) An enzyme containing tightly bound metal ions essential for activity

2004

74. Magnesium ($Mg^{\{2+\}}$) is fundamentally required for the activity of most enzymes utilizing which substrate?
(A) ATP
(B) Lipids
(C) Glycogen
(D) Cholesterol

(B) Lyases require ATP, whereas hydrolases do not
(C) Lyases transfer functional groups, while hydrolases transfer electrons
(D) Lyases strictly require metal ions, while hydrolases require vitamins

2016

54. Fumarase catalyzes the hydration of fumarate to malate. It is best classified as a(n):
(A) Oxidoreductase
(B) Isomerase
(C) Ligase
(D) Lyase

2019

55. Epimerases and racemases are subclasses of which major enzyme group?
(A) Transferases
(B) Isomerases
(C) Hydrolases
(D) Translocases

2004

56. DNA ligase, which forms phosphodiester bonds to join DNA strands using ATP, falls under EC class:
(A) EC 3
(B) EC 4
(C) EC 6
(D) EC 5

2016

57. Which class of enzymes was most recently added as EC Class 7 to represent membrane transport proteins?
(A) Transaminases
(B) Topoisomerases
(C) Transcriptases
(D) Translocases

2012

58. Mutases, which catalyze the intramolecular shift of a chemical group, belong to the class of:
(A) Isomerases
(B) Transferases
(C) Ligases
(D) Lyases

2021

59. Synthetases (which require ATP) are fundamentally distinguished from synthases (which do not) by belonging to which class?
(A) Lyases
(B) Transferases
(C) Hydrolases
(D) Ligases

2006

60. Consider the following statements about enzyme classes:
I. Hydrolases utilize water to break chemical bonds.
II. Lyases create double bonds by removing groups without water.
III. Isomerases catalyze geometric or structural changes within a single molecule.
IV. Ligases couple bond formation to the hydrolysis of ATP.
Which of the above statement(s) is/are correct?
(A) I and II
(B) III only
(C) IV only
(D) I, II, III and IV

2013

61. The "Lock-and-Key" model of enzyme action was first proposed by:
(A) Emil Fischer
(B) Daniel Koshland
(C) Leonor Michaelis
(D) Linus Pauling

2016

62. What is the fundamental assumption of the lock-and-key hypothesis?
(A) The active site is structurally flexible
(B) The substrate dramatically changes shape upon binding
(C) The active site is completely complementary to the substrate prior to binding
(D) The enzyme relies entirely on metal ions for binding

2013

63. Which model postulates that the initial binding of substrate induces a conformational change in the enzyme's active site?
(A) Lock-and-key model
(B) Transition state stabilization model
(C) Michaelis-Menten model
(D) Induced-fit hypothesis

2009

64. Daniel Koshland is credited with formulating which structural model of enzyme catalysis?
(A) The rigid template model
(B) The ping-pong bi-bi mechanism
(C) The induced-fit hypothesis
(D) The concerted allosteric model

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(D) High affinity of the enzyme for its substrate

2017

87. Under what condition is the reaction rate (v) equal to $\frac{V_{max}}{2}$?

(A) When $[S] \gg K_m$
(B) When $[S] = K_m$
(C) When $[S] \ll K_m$
(D) When $[E] = [S]$

2011

88. In steady-state kinetics, what happens to the velocity when substrate concentration $[S]$ greatly exceeds K_m?
(A) The velocity becomes highly dependent on $[S]$
(B) The velocity approaches zero
(C) The reaction follows zero-order kinetics with respect to substrate
(D) The reaction follows first-order kinetics with respect to substrate

2021

89. Which variable in the Michaelis-Menten equation depends directly on total enzyme concentration?
(A) K_m
(B) The ratio $\frac{K_m}{V_{max}}$
(C) The specificity constant
(D) $V_{\{}\max_{\}}$

2015

90. Match the linearized kinetic plot in List I with its mathematical axes in List II.
List I: (Kinetic Plot)
P. Lineweaver-Burk
Q. Eadie-Hofstee
R. Hanes-Woolf
S. Michaelis-Menten (non-linear)
List II: (Mathematical Axes)
1. v versus $\frac{v}{[S]}$
2. $\frac{1}{v}$ versus $\frac{1}{[S]}$
3. v versus $[S]$
4. $\frac{[S]}{v}$ versus $[S]$

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

NODIA

2022

91. In a Lineweaver-Burk double reciprocal plot, what does the y-intercept represent?
(A) $\frac{1}{K_m}$
(B) $\frac{1}{V_{max}}$
(C) $-\frac{1}{K_m}$
(D) $\frac{V_{max}}{K_m}$

2025

92. The x-intercept of a Lineweaver-Burk plot provides the value for:
(A) $-\frac{1}{K_m}$
(B) $\frac{1}{V_{max}}$
(C) $\frac{K_m}{V_{max}}$
(D) $V_{\{}\max_{\}}$

2022

93. Why is the Eadie-Hofstee plot sometimes preferred over the Lineweaver-Burk plot?
(A) It does not compress data at high substrate concentrations, minimizing error distortion
(B) It requires fewer data points to construct
(C) It forms a parabolic curve rather than a straight line
(D) It is completely insensitive to competitive inhibition

2017

94. In the Hanes-Woolf plot ($\frac{[S]}{v}$ versus $[S]$), the slope of the line equals:
(A) $\frac{K_m}{V_{max}}$
(B) $-K_m$
(C) $\frac{1}{V_{max}}$
(D) $\frac{1}{K_m}$

2011

95. The turnover number of an enzyme is mathematically represented as:
(A) K_m
(B) $V_{\{}\max_{\}}$
(C) $\frac{k_{cat}}{K_m}$

2012

139. Aspartate Aminotransferase (AST/SGOT) is found in significant amounts in the liver and which other organ?
(A) Heart
(B) Spleen
(C) Bone
(D) Stomach

2021

140. Match the diagnostic serum enzyme in List I with the primary pathology it indicates in List II.
List I: (Serum Enzyme)
P. CPK-MB
Q. ALT (SGPT)
R. Alkaline Phosphatase
S. Amylase
List II: (Pathology)
1. Liver parenchymal damage
2. Acute pancreatitis
3. Myocardial infarction
4. Obstructive jaundice
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

2013

141. The immobilization of enzymes is a bioprocessing technique designed primarily to:
(A) Restrict enzyme mobility, allowing for reuse and continuous operation
(B) Decrease the optimal temperature of the enzyme
(C) Increase the solubility of enzymes in organic solvents
(D) Ensure irreversible product binding

2025

142. Which enzyme immobilization method involves physically trapping the enzyme within a porous polymer matrix, such as calcium alginate?
(A) Adsorption
(B) Entrapment
(C) Covalent binding
(D) Cross-linking

2004

143. Immobilization via covalent binding generally utilizes which functional groups on the enzyme surface?
(A) Nonpolar hydrocarbon chains
(B) Inert backbone peptide bonds
(C) Specifically the active site catalytic residues
(D) Amino groups of lysine or sulfhydryl groups of cysteine

2025

144. What is a common kinetic consequence of immobilizing an enzyme?
(A) A dramatic decrease in operational stability
(B) An absolute shift to non-competitive inhibition
(C) Mass transfer limitations leading to an increased apparent K_m
(D) A permanent decrease in total $V_{\{}\max_{\}}$ to zero

2019

145. Immobilization by physical adsorption involves which type of interactions?
(A) Irreversible covalent bonds
(B) Weak interactions such as van der Waals forces and ionic bonds
(C) Peptide bond cross-linking
(D) Matrix entrapment

2005

146. Which of the following represents an advantage of cross-linking as an immobilization technique?
(A) It requires highly pure enzymes
(B) It fundamentally alters the optimal pH to neutral
(C) It prevents any conformational changes during catalysis
(D) It does not require a solid support matrix, reducing bulk

2001

147. Bioreactor kinetics with immobilized enzymes frequently must account for which transport phenomenon?
(A) Diffusion of substrate into the immobilization matrix
(B) Active transport against a gradient
(C) Complete osmosis of water
(D) Membrane potential depolarization

2019

148. Microbial amylases are extensively utilized industrially in the production of:
(A) Cheese and dairy products
(B) Leather softening agents
(C) High-fructose corn syrup and textiles
(D) Biodegradable plastics

2023

149. In the dairy industry, which specific microbial enzyme is widely used as a rennet substitute to coagulate milk?
(A) Protease (e.g., mucorpepsin)

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2005

107. What is the characteristic effect of an uncompetitive inhibitor on kinetic parameters?
(A) It decreases $V_{\{}\max_{\}}$ but increases apparent K_m
(B) It increases both $V_{\{}\max_{\}}$ and apparent K_m
(C) It leaves $V_{\{}\max_{\}}$ unchanged while increasing apparent K_m
(D) It decreases both $V_{\{}\max_{\}}$ and apparent K_m proportionally

2016

108. A Lineweaver-Burk plot displaying parallel lines at varying inhibitor concentrations indicates which type of inhibition?
(A) Competitive
(B) Uncompetitive
(C) Non-competitive
(D) Mixed

2006

109. Irreversible inhibitors commonly inactivate enzymes by forming which type of interaction?
(A) Strong covalent bonds with active site residues
(B) Weak hydrogen bonds
(C) Transient electrostatic interactions
(D) Hydrophobic interactions at an allosteric site

2005

110. Consider the following statements regarding inhibitors:
I. Mechanism-based inactivators are also called suicide inhibitors.
II. Suicide inhibitors are unreactive until the enzyme attempts to catalyze their conversion.
III. Affinity labels structurally resemble the substrate but react covalently.
IV. Irreversible inhibitors can be completely removed by extensive dialysis.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I and II
(C) III and IV
(D) IV only

2025

111. Diisopropyl fluorophosphate (DIPF) acts as an irreversible inhibitor by reacting with the hydroxyl group of which amino acid?
(A) Cysteine
(B) Histidine
(C) Aspartate
(D) Serine

2010

112. Transition-state analogs are potent inhibitors because they:
(A) Denature the secondary structure of the enzyme
(B) Rapidly degrade the enzyme's prosthetic group
(C) Bind more tightly to the active site than the substrate does
(D) Form highly unstable complexes with the enzyme

2017

113. Penicillin inhibits bacterial cell wall synthesis by acting as a:
(A) Reversible competitive inhibitor
(B) Mechanism-based (suicide) inactivator
(C) Reversible uncompetitive inhibitor
(D) Non-competitive allosteric inhibitor

2011

114. Suicide inhibitors are distinguished from generic affinity labels because suicide inhibitors:
(A) Are highly reactive molecules in their native state
(B) Bind reversibly to the allosteric regulatory site
(C) Cause premature release of the final product
(D) Hijack the normal catalytic mechanism to generate a reactive intermediate

2019

115. Allosteric enzymes typically do not conform to Michaelis-Menten kinetics. Instead, their v vs. $[S]$ curves are typically:
(A) Sigmoidal
(B) Linear
(C) Hyperbolic
(D) Parabolic

NODIA

2016

116. In allosteric regulation, a homotropic effector is defined as:
(A) A molecule completely structurally unrelated to the substrate
(B) A metal ion necessary for catalytic function
(C) A regulatory molecule that is also the enzyme's normal substrate
(D) An irreversible inhibitor

2009

117. The concerted (MWC) model for allosteric enzymes proposes that:
(A) The enzyme exists in an equilibrium between

2003

75. In biological redox reactions, which transition metals are most frequently utilized by enzymes due to their variable oxidation states?
(A) Sodium and Potassium
(B) Calcium and Magnesium
(C) Zinc and Cadmium
(D) Iron and Copper

2009

76. Cytochrome oxidase relies on which essential metal ions to facilitate the final step of the electron transport chain?
(A) Zinc and Manganese
(B) Copper and Iron
(C) Magnesium and Calcium
(D) Molybdenum and Cobalt

2015

77. Thiamine pyrophosphate (TPP) is a coenzyme derived from which vitamin?
(A) Vitamin B_1
(B) Vitamin B_2
(C) Vitamin B_6
(D) Vitamin B_{12}

2002

78. Pyridoxal phosphate (PLP) is critical for which type of enzymatic reactions?
(A) Oxidative decarboxylation
(B) Methyl group transfer
(C) Transamination of amino acids
(D) ATP hydrolysis

2009

79. NAD+ and NADP+ are coenzymes derived from which precursor?
(A) Niacin
(B) Riboflavin
(C) Pantothenic acid
(D) Folic acid

2014

80. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Coenzyme A (CoA) is primarily involved in acyl group transfer reactions.
Reason (R): Coenzyme A possesses a reactive sulfhydryl (-SH) group that forms thioester bonds.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

81. FAD and FMN are derived from which essential vitamin?
(A) Vitamin B_1 (Thiamine)
(B) Vitamin B_2 (Riboflavin)
(C) Vitamin B_3 (Niacin)
(D) Vitamin C (Ascorbic acid)

2007

82. What is the specific biochemical function of tetrahydrofolate (THF)?
(A) Two-carbon acetyl group transfer
(B) Electron transport
(C) Phosphate transfer
(D) One-carbon group transfer

2018

83. The derivation of the Michaelis-Menten equation fundamentally assumes a "steady state," which implies:
(A) The rate of ES complex formation equals the rate of its breakdown
(B) The concentration of substrate remains absolutely constant
(C) The enzyme concentration is much greater than the substrate concentration
(D) The reaction is fully reversible at all times

2016

84. In the Michaelis-Menten equation, $V_{\{}\max_{\}}$ represents the maximal velocity attained when:
(A) Substrate concentration is equal to K_m
(B) The enzyme concentration is minimal
(C) The enzyme is completely saturated with substrate
(D) Half of the active sites are occupied

2002

85. What is the definition of the Michaelis constant (K_m)?
(A) The substrate concentration at which the reaction velocity is half of $V_{\{}\max_{\}}$
(B) The substrate concentration at which velocity is maximal
(C) The dissociation constant of the enzyme-product complex
(D) The maximum turnover number of the enzyme

2008

86. A low K_m value indicates:
(A) Low affinity of the enzyme for its substrate
(B) A slow catalytic turnover rate
(C) The enzyme requires an allosteric activator

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(C) Because their active sites cannot form without dietary substrates
(D) To prevent premature degradation of the tissues that synthesize them

2019

128. Adenylylation regulates the activity of which key metabolic enzyme in E. coli?
(A) Hexokinase
(B) Phosphofructokinase
(C) Glutamine synthetase
(D) RNA polymerase

2004

129. Isoenzymes (isozymes) are broadly defined as:
(A) Enzymes from different species catalyzing identical reactions
(B) Different structural forms of an enzyme within a single organism that catalyze the same reaction
(C) Structurally identical enzymes that catalyze entirely different reactions
(D) Inactive enzyme precursors

2002

130. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Isoenzymes often display distinct kinetic parameters (K_m, $V_{\{}\max_{\}}$) and regulatory properties.
Reason (R): Isoenzymes are encoded by different genes or arise from distinct combinations of multiple subunits.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

131. Lactate dehydrogenase (LDH) exists in tissues as a tetramer composed of which two primary subunit types?
(A) M (Muscle) and H (Heart)
(B) Alpha and Beta
(C) X and Y
(D) Slow and Fast

2005

132. How many distinct tetrameric isoenzymes of lactate dehydrogenase exist?
(A) Three
(B) Four
(C) Five
(D) Six

2019

133. The LDH-1 isoenzyme (predominantly H_4) is found in highest concentration in the:
(A) Heart muscle
(B) Skeletal muscle
(C) Liver
(D) Lung

2017

134. Physiologically, the M-rich LDH isoenzymes are optimized for which condition?
(A) Aerobic oxidation of lactate to pyruvate
(B) Irreversible transamination reactions
(C) Storage of glucose as glycogen
(D) Anaerobic reduction of pyruvate to lactate

2012

135. Creatine phosphokinase (CPK) exists as a dimer. Which isoenzyme is highly specific to heart tissue and serves as a diagnostic marker for myocardial infarction?
(A) CPK-MM
(B) CPK-MB
(C) CPK-BB
(D) CPK-HH

2008

136. Elevated serum levels of Alanine Aminotransferase (ALT/SGPT) are most indicative of damage to which organ?
(A) Heart
(B) Brain
(C) Liver
(D) Pancreas

2018

137. Which clinical condition is most strongly associated with highly elevated serum Alkaline Phosphatase (ALP) levels?
(A) Myocardial infarction
(B) Acute pancreatitis
(C) Muscular dystrophy
(D) Biliary obstruction and bone disorders

2006

138. Diagnostic enzymology relies on the fact that intracellular enzymes:
(A) Leak into the systemic circulation following cellular injury or necrosis
(B) Are continuously actively secreted into the bloodstream
(C) Function optimally in the blood plasma
(D) Mutate rapidly during infections

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distinct T (tense) and R (relaxed) states
(B) Subunits change conformation sequentially, one by one
(C) Ligand binding induces the complete denaturation of the enzyme
(D) The active site fundamentally migrates to a different domain

2024

118. According to the sequential (KNF) model of allosterism:
(A) All subunits must transition from T to R simultaneously
(B) The enzyme completely lacks a T state
(C) Subunits operate completely independently without communication
(D) Binding of a ligand to one subunit alters the conformation of that specific subunit and influences its neighbors

2015

119. Heterotropic allosteric effectors alter enzyme activity by:
(A) Binding covalently to the active site
(B) Binding to regulatory sites distinct from the active site
(C) Competing directly with the substrate at the active site
(D) Promoting complete structural degradation of the enzyme

2011

120. Consider the following statements about allosteric models:
I. The MWC model allows for hybrid conformational states containing both T and R subunits.
II. The KNF model permits individual subunits to undergo conformational changes sequentially.
III. The T state possesses lower affinity for the substrate than the R state.
IV. Homotropic effectors generally act as positive allosteric modulators.
V. Sigmoidal kinetics reflect cooperativity between subunits.
Which of the above statement(s) is/are correct?
(A) II, III, IV and V
(B) I, II, III and V
(C) I, III, IV and V
(D) II, IV and V

2017

121. The most widespread form of reversible covalent modification used to regulate enzyme activity in eukaryotes is:
(A) Methylation
(B) Adenylylation
(C) Acetylation
(D) Phosphorylation

2025

122. Protein kinases regulate enzymes by catalyzing the transfer of a phosphate group, typically from ATP, to specific residues of:
(A) Serine, Threonine, and Tyrosine
(B) Glycine, Alanine, and Valine
(C) Cysteine and Methionine
(D) Aspartate and Glutamate

2006

123. The action of protein kinases is functionally reversed by which class of enzymes?
(A) Phosphorylases
(B) Ligases
(C) Synthetases
(D) Phosphatases

2002

124. Glycogen phosphorylase is uniquely regulated by both allosteric effectors and:
(A) Irreversible zymogen activation
(B) Reversible covalent phosphorylation
(C) Covalent adenylylation
(D) Non-competitive metal binding

NODIA

2016

125. Zymogen activation differs from phosphorylation-based regulation primarily because zymogen activation is:
(A) Physiologically irreversible
(B) Strictly reversible
(C) Dependent entirely on ATP
(D) Executed by phosphatases

2014

126. Chymotrypsinogen is converted to fully active alpha-chymotrypsin through:
(A) Reversible phosphorylation
(B) Binding of a homotropic effector
(C) Specific proteolytic cleavage
(D) Addition of a prosthetic group

2011

127. Why are many digestive proteases synthesized as inactive zymogens?
(A) To save cellular energy during translation
(B) Because they require exposure to high oxygen levels to fold

(B) Lipase
(C) Cellulase
(D) Pectinase

2004

150. Select the correct operational sequence for the complete enzymatic breakdown of starch to glucose in industrial bioprocessing.
(A) Liquefaction by alpha-amylase → Saccharification by glucoamylase → Isomerization (if making syrup)
(B) Saccharification by glucoamylase → Liquefaction by alpha-amylase → Isomerization
(C) Isomerization → Liquefaction by alpha-amylase → Saccharification by glucoamylase
(D) Liquefaction by glucoamylase → Saccharification by alpha-amylase → Isomerization

2004

151. Alkaline proteases are prominently featured as active ingredients in:
(A) Baking flour improvements
(B) Biological laundry detergents
(C) Fruit juice clarification
(D) Wine fermentation

2001

152. Pectinases are highly valued in the beverage industry primarily for:
(A) Synthesizing complex carbohydrates
(B) Enhancing the alcoholic content of wines
(C) Preventing lipid oxidation
(D) Clarifying fruit juices by degrading plant cell wall components

2010

153. Industrial lipases are deployed in the synthesis of which modern renewable energy source?
(A) Bioethanol
(B) Biogas
(C) Hydrogen fuel
(D) Biodiesel

2022

154. Restriction endonucleases generally recognize specific DNA sequences that are structurally:
(A) Palindromic
(B) Homopolymeric
(C) Randomly organized
(D) Rich solely in AT base pairs

2006

155. Which class of restriction endonucleases cleaves DNA precisely within or near specific recognized palindromic sequences without requiring ATP?
(A) Type I
(B) Type III
(C) Type IV
(D) Type II

2018

156. Arrange the following genetic engineering tools in the correct logical sequence of their typical application during recombinant plasmid construction:
I. Transformation of host cells
II. Digestion of vector and insert with restriction endonucleases
III. Ligation of the DNA fragments with DNA ligase
IV. Selection of recombinant clones
(A) II, III, I, IV
(B) I, II, III, IV
(C) II, I, III, IV
(D) III, II, I, IV

2011

157. Type I restriction endonucleases differ from Type II because Type I enzymes:
(A) Cleave DNA at random sites far away from their recognition sequence
(B) Do not require any cofactors
(C) Are entirely composed of RNA
(D) Cut only single-stranded DNA

2021

158. DNA ligases facilitate the joining of DNA strands by catalyzing the formation of:
(A) Hydrogen bonds between complementary bases
(B) Peptide bonds between histones
(C) Phosphodiester bonds between a 3'-OH and a 5'-phosphate
(D) Disulfide bridges between adjacent strands

2014

159. In genetic engineering, reverse transcriptase is an indispensable enzyme used primarily to synthesize:
(A) mRNA from a genomic DNA template
(B) Proteins directly from a viral RNA genome
(C) Ribosomal RNA
(D) Complementary DNA (cDNA) from an mRNA template

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(A) They are identical in every human tissue
(B) They exhibit distinct tissue-specific expression patterns
(C) They never leak into the bloodstream
(D) They uniquely cure viral infections

2024

205. Elevated serum Lactate Dehydrogenase (LDH) levels featuring an "LDH flip" (LDH-1 > LDH-2) historically indicated:
(A) Acute myocardial infarction
(B) Hepatitis
(C) Pulmonary embolism
(D) Muscular dystrophy

2009

206. Amylase and lipase levels are routinely measured simultaneously to reliably diagnose:
(A) Chronic kidney failure
(B) Hypothyroidism
(C) Acute pancreatitis
(D) Multiple sclerosis

2021

207. Which immobilization matrix is a naturally derived polysaccharide commonly used for gentle entrapment of fragile cells and enzymes?
(A) Polyacrylamide
(B) Polystyrene
(C) Silica gel
(D) Alginate

2013

208. Covalent coupling of an enzyme to a support matrix often utilizes which bifunctional cross-linking reagent?
(A) Sodium dodecyl sulfate
(B) Beta-mercaptoethanol
(C) Glutaraldehyde
(D) Ethidium bromide

2015

209. The "effectiveness factor" in bioreactor kinetics accounts for:
(A) The loss of enzyme due to denaturation
(B) The ratio of the actual reaction rate to the rate without diffusion limitations
(C) The cost efficiency of the immobilization matrix
(D) The purity of the final product

2021

210. Consider the following statements concerning industrial enzymes:
I. Amylases break down complex starches into simpler sugars.
II. Pectinases clarify juices by breaking down plant cell wall polymers.
III. Alkaline proteases are avoided in detergents due to instability.
IV. Lipases are utilized for biodiesel synthesis.
V. Cellulases are extensively used in the paper and pulp industry.
Which of the above statement(s) is/are correct?
(A) I, II, III and V
(B) I, II, IV and V
(C) II, III, IV and V
(D) I, III, IV and V

2001

211. Cellulases function industrially to break down cellulose into:
(A) Glucose
(B) Fructose
(C) Sucrose
(D) Galactose

2007

212. Type II restriction endonucleases typically cleave DNA to produce:
(A) Only sticky (cohesive) ends
(B) Only blunt ends
(C) Either sticky or blunt ends depending on the specific enzyme
(D) RNA fragments

2008

213. The natural biological function of restriction endonucleases in bacteria is to:
(A) Protect against invading viral (bacteriophage) DNA
(B) Aid in bacterial DNA replication
(C) Facilitate horizontal gene transfer
(D) Degrade damaged mRNA

NODIA

2004

214. How does a bacterial cell prevent its own restriction enzymes from cleaving its genomic DNA?
(A) By sequestering the enzymes in specialized organelles
(B) By maintaining a low internal temperature
(C) By utilizing single-stranded DNA exclusively
(D) By methylating specific bases within the recognition sequences

2023

215. Reverse transcriptase requires which short molecule to initiate cDNA synthesis?
(A) An RNA polymerase
(B) A short complementary primer
(C) A restriction endonuclease

Assertion (A): Thermostable enzymes maintain their tertiary structure at elevated temperatures.
Reason (R): Thermostable enzymes possess significantly increased numbers of ionic networks, disulfide bonds, and hydrophobic interactions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

171. Ribozymes demonstrate that catalytic capability is not the exclusive domain of:
(A) Nucleic acids
(B) Proteins
(C) Lipids
(D) Carbohydrates

2024

172. The term "abzyme" is specifically derived from the fusion of which two words?
(A) Abnormal enzyme
(B) Antibody enzyme
(C) Absolute enzyme
(D) Abiotic enzyme

2017

173. What distinguishes an abzyme's binding mechanism from a traditional antibody?
(A) The abzyme specifically binds and stabilizes the transition state of a target reaction
(B) The abzyme binds only non-biological foreign antigens
(C) The abzyme strictly avoids binding any target permanently
(D) The abzyme binds strictly to DNA sequences

2005

174. In the context of enzyme kinetics, a high E_a (activation energy) generally corresponds to:
(A) A rapid reaction rate
(B) An irreversible reaction
(C) A slow reaction rate
(D) An highly exergonic reaction

2017

175. When assessing the thermodynamics of a reaction, if $\Delta G = 0$, the system is:
(A) Proceeding rapidly in the forward direction
(B) Completely halted and dead
(C) Operating at $V_{\max}$
(D) At chemical equilibrium

2005

176. Which state must a reacting molecule achieve for a chemical reaction to occur?
(A) Ground state
(B) Equilibrium state
(C) Transition state
(D) Standard state

2024

177. The Arrhenius equation connects which two parameters?
(A) Reaction rate and substrate concentration
(B) Reaction rate constant and activation energy
(C) Activation energy and Gibbs free energy
(D) Enthalpy and entropy

2010

178. Enzyme specificity is primarily governed by the three-dimensional arrangement of amino acids within the:
(A) Allosteric site
(B) N-terminus only
(C) Polypeptide backbone
(D) Active site

2023

179. A co-substrate generally acts by:
(A) Temporarily carrying a chemical group between different enzymes
(B) Becoming permanently modified after one catalytic cycle
(C) Preventing substrate binding
(D) Covalently linking two enzyme subunits

2011

180. Match the coenzyme in List I with the group it transfers in List II.
List I: (Coenzyme)
P. NAD+
Q. ATP
R. Coenzyme A
S. Tetrahydrofolate
List II: (Transferred Group)
1. Acyl groups
2. Electrons/Hydride ions
3. One-carbon groups
4. Phosphate groups
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-2, R-3, S-4

2018

181. Under IUBMB nomenclature, which enzyme class is designated by the EC number 5?
(A) Isomerases

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(B) Ligases
(C) Lyases
(D) Translocases

2010

182. A peptidase breaking down dietary proteins into amino acids is classified as a:
(A) Lyase
(B) Transferase
(C) Ligase
(D) Hydrolase

2011

183. Decarboxylases, which remove carbon dioxide from amino acids, belong to the class of:
(A) Transferases
(B) Isomerases
(C) Lyases
(D) Oxidoreductases

2001

184. The "induced fit" model heavily relies on the concept of:
(A) Structural rigidity
(B) Irreversible denaturation
(C) Isomerases
(D) Conformational flexibility

2016

185. A classic example of an enzyme functioning via the lock-and-key model is often considered to be highly rigid. Which type of enzymes might approximate this?
(A) Highly specific proteases recognizing small rigid substrates
(B) Broad-spectrum kinases
(C) Large allosteric complexes
(D) Flexible multi-domain synthetases

2002

186. In proximity and orientation catalysis, the enzyme accelerates the reaction by:
(A) Decreasing the entropy of the reacting molecules
(B) Increasing the entropy of activation
(C) Adding water to the active site
(D) Raising the local temperature

2012

187. In general acid catalysis, the amino acid acting as the acid must:
(A) Accept a proton
(B) Form a covalent bond
(C) Be a positively charged metal ion
(D) Donate a proton

2013

188. Which characteristic defines a true metalloenzyme over a metal-activated enzyme?
(A) The metal ion is tightly retained during isolation and purification
(B) The metal ion acts as a weak allosteric inhibitor
(C) The enzyme strictly requires sodium or potassium
(D) The metal ion is rapidly exchanged with the solvent

NODIA

2004

189. Vitamin C (ascorbic acid) acts as a coenzyme in the synthesis of which major structural protein by functioning in hydroxylation reactions?
(A) Collagen
(B) Keratin
(C) Elastin
(D) Actin

2012

190. Consider the following statements about vitamins and coenzymes:
I. Pantothenic acid is a structural component of Coenzyme A.
II. Folic acid deficiency impairs one-carbon transfer reactions.
III. Biotin specifically facilitates transamination reactions.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2016

191. What is the fundamental shape of a Michaelis-Menten kinetic curve mapping v against $[S]$?
(A) Linear
(B) Sigmoidal
(C) Exponential decay
(D) Rectangular hyperbola

2025

192. Which enzyme kinetic parameter directly indicates the maximum number of substrate molecules converted to product per second by a single active site?
(A) K_m
(B) $V_{\{}\max_{\}}$
(C) $k_{\{cat\}}$
(D) $K_{\{eq\}}$

2017

193. The Hanes-Woolf plot generates a straight line. What does the y-intercept of this plot represent?

(A) $\frac{1}{V_{\max}}$

(B) $\frac{K_m}{V_{\max}}$

(C) $-K_m$

(D) $\frac{1}{K_m}$

2008

194. Why does an enzyme with a high $\frac{k_{cat}}{K_m}$ ratio operate efficiently at low substrate concentrations?

(A) Because it has a very low turnover number
(B) Because it avoids transition state formation
(C) Because it relies on uncompetitive inhibition
(D) Because it binds the substrate with high affinity and converts it rapidly

2007

195. In the presence of a pure non-competitive inhibitor, the Lineweaver-Burk plot shows lines intersecting at:

(A) The x-axis
(B) The y-axis
(C) A point in the second quadrant
(D) A point in the third quadrant

2010

196. The hallmark of mixed inhibition is that the inhibitor:

(A) Only binds the free enzyme
(B) Only binds the ES complex
(C) Binds both free enzyme and ES complex, but with unequal affinities
(D) Mimics the transition state permanently

2021

197. Heavy metal toxicity (e.g., Lead or Mercury poisoning) often results from which type of enzyme inhibition?

(A) Irreversible binding to sulfhydryl groups
(B) Competitive reversible
(C) Uncompetitive allosteric
(D) Mechanism-based inactivation

2001

198. Nerve gases like Sarin are potent, lethal agents primarily because they act as:

(A) Reversible competitive inhibitors of acetylcholine
(B) Allosteric activators of proteases
(C) Suicide inhibitors of DNA polymerase
(D) Irreversible inhibitors of acetylcholinesterase

2024

199. An allosteric enzyme exhibiting positive cooperativity will display what kind of Hill coefficient (n_H)?

(A) $n_H < 1$
(B) $n_H > 1$
(C) $n_H = 1$
(D) $n_H = 0$

2016

200. Consider the following statements on enzyme regulation:

I. Phosphorylation typically targets Ser, Thr, or Tyr residues.
II. Zymogen activation requires ATP hydrolysis.
III. Allosteric modulators bind to the active site.
IV. Covalent modification can either activate or inhibit target enzymes.

Which of the above statement(s) is/are correct?

(A) I and IV
(B) II and III
(C) I, II, and III
(D) III only

2007

201. Which protein is centrally involved in binding calcium ions to regulate various kinases and phosphatases?

(A) Ubiquitin
(B) Cytochrome C
(C) Myoglobin
(D) Calmodulin

2002

202. The intrinsic pathway of blood coagulation heavily relies on which mechanism of enzyme regulation?

(A) Sequential zymogen activation (a proteolytic cascade)
(B) Reversible phosphorylation
(C) Transcriptional downregulation
(D) Irreversible inhibition by suicide substrates

2003

203. Genetic origins of isoenzymes often involve:

(A) Silent point mutations that do not affect the amino acid sequence
(B) The absolute loss of introns
(C) Horizontal gene transfer strictly from viruses
(D) Gene duplication events leading to divergent paralogs

2011

204. Why are specific isoenzyme profiles medically useful for diagnostic purposes?

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2018

227. The first digit of the EC number for a generic phosphatase (which cleaves a phosphate group using water) is:
(A) 3
(B) 1
(C) 2
(D) 4

2019

228. Dehydrogenases are classified under which overarching EC group?
(A) Transferases
(B) Lyases
(C) Oxidoreductases
(D) Isomerases

2004

229. Transaminases, which shuffle an amino group from an amino acid to a keto acid, require which vitamin derivative as a coenzyme?
(A) Pyridoxal phosphate (PLP)
(B) Thiamine pyrophosphate (TPP)
(C) Tetrahydrofolate (THF)
(D) Cobalamin

2004

230. Match the catalytic mechanism in List I with its core feature in List II.
List I: (Catalytic Mechanism)
P. Covalent catalysis
Q. General acid-base catalysis
R. Metal ion catalysis
S. Proximity effects
List II: (Core Feature)
1. Electron withdrawal by a fixed cationic center
2. Formation of a transient electron-sharing bond
3. Bringing reactive functional groups close together
4. Proton transfer directly from an amino acid side chain
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-3, R-2, S-4

2007

231. The Michaelis-Menten kinetic model is strictly valid only when investigating:
(A) Multi-substrate allosteric reactions
(B) Initial reaction velocities where product concentration is negligible
(C) Reactions running backwards at equilibrium
(D) Irreversible degradation reactions

2005

232. In the Lineweaver-Burk equation, the slope of the line is defined as:
(A) $\frac{1}{V_{\max}}$
(B) $\frac{V_{\max}}{K_m}$
(C) $\frac{K_m}{V_{\max}}$
(D) $\frac{1}{K_m}$

NODIA

2022

233. The Eadie-Hofstee plot expresses v against:
(A) $[S]$
(B) $\frac{1}{[S]}$
(C) $\frac{[S]}{v}$
(D) $\frac{v}{[S]}$

2017

234. If an inhibitor binds solely to the free enzyme but not the ES complex, the inhibition is categorized strictly as:
(A) Competitive
(B) Non-competitive
(C) Uncompetitive
(D) Irreversible suicide

2009

235. During competitive inhibition, increasing the substrate concentration to very high levels will:
(A) Fail to restore $V_{\{}\max_{\}}$
(B) Denature the enzyme
(C) Convert the inhibitor to a substrate
(D) Fully overcome the inhibition and achieve the original $V_{\{}\max_{\}}$

2007

236. Non-competitive inhibition effectively reduces the pool of:
(A) Total free substrate in the medium
(B) Active enzyme molecules capable of reaching $V_{\{}\max_{\}}$
(C) Irreversible inhibitors
(D) Metal cofactors

2011

237. Which statement perfectly characterizes uncompetitive inhibition?
(A) The inhibitor requires the substrate to bind the enzyme first to create its binding site
(B) The inhibitor prevents substrate binding

(D) A promoter sequence

2024

216. Which specific attribute makes reverse transcriptase highly error-prone?
(A) It incorporates uracil instead of thymine
(B) It heavily relies on mismatched primers
(C) It lacks 3' → 5' exonuclease proofreading activity
(D) It constantly dissociates from the template

2014

217. In the context of PCR, the denaturation step achieved at $95^{\circ}C$ aims to:
(A) Activate the DNA polymerase
(B) Anneal primers to the template
(C) Synthesize the new complementary strand
(D) Separate the double-stranded DNA into single strands

2009

218. The "annealing" temperature in a typical PCR protocol is primarily determined by:
(A) The length and GC-content of the specific primers
(B) The concentration of Taq polymerase
(C) The age of the DNA sample
(D) The amount of dNTPs present

2018

219. Thermostability in enzymes like Taq polymerase is a result of structural adaptations including:
(A) High overall structural flexibility
(B) Increased core hydrophobicity and extensive salt bridge networks
(C) Absence of secondary structural elements like alpha helices
(D) Heavy glycosylation

2001

220. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The specificity constant ($\frac{k_{cat}}{K_m}$) has an upper physical limit determined by the rate of diffusion.
Reason (R): An enzyme cannot catalyze a reaction faster than it can randomly collide with a substrate molecule in solution.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

221. Which enzymatic index provides the best comparison of an enzyme's preference for competing alternative substrates?
(A) The ratio $\frac{k_{cat}}{K_m}$
(B) The raw $V_{\{}\max_{\}}$ value
(C) The pure K_m value
(D) The apparent molecular weight

2006

222. An abzyme generated against a transition-state analog of an ester hydrolysis reaction will likely function as a(n):
(A) Ligase
(B) Oxidoreductase
(C) Esterase
(D) Polymerase

2008

223. What thermodynamic parameter is solely represented by the height of the energy peak between reactants and products?
(A) Enthalpy of reaction
(B) Entropy of reaction
(C) Standard free energy change
(D) Activation energy (E_a)

2021

224. Absolute specificity implies that an enzyme will act upon:
(A) Any molecule containing a specific functional group
(B) Only D-isomers but never L-isomers
(C) Exclusively one single specific substrate
(D) Both structural enantiomers equally

NODIA

2001

225. Glucokinase and hexokinase are classic examples of isoenzymes that differ predominantly in their:
(A) Major functional class (EC number)
(B) Affinity (K_m) for glucose and tissue distribution
(C) Requirement for water
(D) Metal ion cofactor preference

2018

226. A prosthetic group is functionally and structurally analogous to a:
(A) Reversible competitive inhibitor
(B) Transiently binding co-substrate
(C) Free floating regulatory lipid
(D) Covalently attached coenzyme

2007

250. EcoRI is a widely used Type II restriction enzyme that leaves:
(A) 5' overhanging sticky ends
(B) 3' overhanging sticky ends
(C) Perfectly flush blunt ends
(D) Circular single-stranded ends

2002

251. Isoschizomers are defined as multiple restriction endonucleases that:
(A) Recognize entirely different sequences but cut identically
(B) Recognize exactly the same sequence and cleave at the same positions
(C) Cut RNA instead of DNA
(D) Require vastly different metal cofactors

2018

252. The fundamental reaction catalyzed by DNA ligase during cloning requires the input of energy directly from:
(A) GTP or CTP
(B) ATP or NAD+
(C) Pyruvate
(D) Glucose

2004

253. In retroviruses, the reverse transcriptase enzyme also exhibits which critical secondary enzymatic activity necessary for viral replication?
(A) RNase H activity (degrading RNA in RNA:DNA hybrids)
(B) DNA ligase activity
(C) Protease activity
(D) Restriction endonuclease activity

2006

254. When synthesizing cDNA, poly-T (oligo-dT) primers are typically employed because they specifically target:
(A) The 5' cap of eukaryotic mRNA
(B) Prokaryotic ribosomal RNA
(C) The 3' poly-A tail of eukaryotic mRNA
(D) Viral single-stranded DNA

2003

255. In the standard PCR cycle, the annealing step generally occurs at what temperature range?
(A) $30 - 40^{\circ} C$
(B) $70 - 75^{\circ} C$
(C) $90 - 95^{\circ} C$
(D) $50 - 65^{\circ} C$

2004

256. Thermostable polymerases like Taq typically lack 3' to 5' exonuclease activity. What is the direct consequence of this deficiency?
(A) The enzyme stops functioning after five cycles
(B) The enzyme is unable to bind the primer
(C) The enzyme generates PCR products with a higher error rate
(D) The enzyme strictly synthesizes RNA

2007

257. An enzyme operating perfectly at $95^{\circ} C$ maintains its folded state primarily through increased numbers of:
(A) Covalent peptide backbone breaks
(B) Internal hydrogen bonds and stabilizing salt bridges
(C) Highly mobile random coil regions
(D) Bound water molecules

2025

258. What is the typical diameter of an enzyme's active site?
(A) 1–2 Å
(B) 10–20 Å
(C) 100–200 Å
(D) 500–1000 Å

2002

259. The self-splicing group I introns discovered by Thomas Cech are classic examples of:
(A) Naturally occurring ribozymes
(B) Protein kinases
(C) Synthetic abzymes
(D) Type I restriction endonucleases

2008

260. Which of the following describes the effect of pH on enzyme activity?
(A) Reaction rate is independent of pH
(B) Most enzymes have a specific optimum pH where activity is maximal
(C) Higher pH always leads to higher activity
(D) Activity decreases linearly as pH increases

2025

261. What is the term for the factor by which the reaction rate increases for every 10-degree Celsius rise in temperature?
(A) K_m
(B) $V_{\{}\mathrm{max}_{\}}$
(C) $Q_{\{10\}}$
(D) Hill coefficient

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directly
(C) The inhibitor binds irreversibly to the active site
(D) The apparent K_m increases substantially

2014

238. Penicillin kills bacteria primarily by irreversibly inhibiting the enzyme:
(A) Beta-lactamase
(B) RNA polymerase
(C) Transpeptidase
(D) DNA gyrase

2006

239. Feedback inhibition in metabolic pathways is typically mediated by:
(A) Irreversible suicide inhibitors
(B) Competitive inhibition by substrate analogs
(C) General acid-base denaturation
(D) Allosteric regulation by the final end-product

2023

240. The sigmoidal velocity curve of an allosteric enzyme fundamentally indicates:
(A) Zero-order kinetics at all substrate concentrations
(B) Rapid enzyme degradation
(C) Cooperative binding among multiple subunits
(D) Complete absence of a regulatory site

2004

241. Phosphorylation of glycogen synthase effectively causes it to become:
(A) Completely destroyed
(B) Inactive
(C) Highly active
(D) A kinase itself

2010

242. Trypsinogen is converted to active trypsin within the small intestine by the action of:
(A) Pepsin
(B) Amylase
(C) Bile salts
(D) Enterokinase (enteropeptidase)

2018

243. Isoenzymes are highly advantageous to an organism because they allow for:
(A) Fine-tuned metabolic regulation tailored to specific tissue conditions
(B) A single gene to produce an unlimited variety of unique proteins
(C) The complete elimination of competitive inhibition
(D) The bypassing of transition states entirely

2007

244. Myocardial infarction is often monitored over time by analyzing a specific temporal pattern of release of which three enzymes?
(A) Amylase, Lipase, and Trypsin
(B) ALT (SGPT), ALP, and GGT
(C) CPK, AST (SGOT), and LDH
(D) Hexokinase, PFK, and Pyruvate kinase

2011

245. High levels of Gamma-Glutamyl Transferase (GGT) in the blood are specifically indicative of:
(A) Alcoholic liver disease and biliary damage
(B) Muscular dystrophy
(C) Acute bone fractures
(D) Myocardial infarction

2024

246. In enzyme immobilization, one distinct disadvantage of covalent binding compared to simple adsorption is:
(A) High risk of enzyme leakage into the product
(B) Inability to be used in continuous flow reactors
(C) Extreme weakness of the bond formed
(D) Potential loss of enzyme activity due to chemical modification of crucial residues

2008

247. The application of enzymes in continuous stirred-tank reactors (CSTR) heavily depends on:
(A) Keeping the enzyme fully dissolved and flushed out continuously
(B) Successful stable immobilization of the biocatalyst
(C) High temperature denaturation
(D) Manual pipetting of fresh enzyme every hour

2011

248. The enzyme glucose isomerase is massive industrially because it converts glucose into:
(A) Galactose
(B) Maltose
(C) Fructose
(D) Sucrose

2002

249. Which microbial enzyme is heavily utilized in the leather industry for "bating" (softening) hides?
(A) Lipase
(B) Amylase
(C) Cellulase
(D) Protease

NODIA

2008

160. Arrange the following steps reflecting the function of reverse transcriptase in constructing a cDNA library:
I. Synthesis of the first DNA strand complementary to mRNA
II. Degradation of the RNA template (RNase H activity)
III. Synthesis of the second complementary DNA strand
IV. Isolation of mature mRNA
(A) IV, I, II, III
(B) I, II, III, IV
(C) IV, II, I, III
(D) I, IV, II, III

2021

161. Reverse transcriptase natively originates from which biological source?
(A) Bacteriophages
(B) Retroviruses
(C) Prokaryotic plasmids
(D) Eukaryotic mitochondria

2006

162. Taq DNA polymerase is extensively utilized in Polymerase Chain Reaction (PCR) because it:
(A) Possesses high processivity at extreme cold temperatures
(B) Acts as a reverse transcriptase
(C) Unwinds double-stranded DNA autonomously
(D) Withstands the high temperatures required for DNA denaturation without irreversible inactivation

2015

163. The primary reason typical mesophilic DNA polymerases are unsuitable for modern PCR is:
(A) They are denatured and destroyed during the $94 - 96^{\circ}C$ heating step
(B) They lack proofreading capability
(C) They require RNA primers
(D) They synthesize DNA in the 3' $\rightarrow$ 5' direction

2021

164. Taq polymerase, originally isolated from Thermus aquaticus, possesses which kinetic limitation?
(A) It requires a continuous supply of ATP
(B) It exhibits a very low turnover number (k_{cat}) at $72^{\circ}C$
(C) It lacks 3' $\rightarrow$ 5' exonuclease (proofreading) activity
(D) It degrades DNA completely after 20 cycles

2008

165. To overcome the lack of proofreading in standard Taq polymerase for high-fidelity PCR, researchers often employ:
(A) Pfu DNA polymerase
(B) Reverse transcriptase
(C) RNA polymerase
(D) DNA ligase

2017

166. A distinct feature of Taq polymerase useful in TA cloning is its tendency to:
(A) Create perfectly blunt-ended DNA fragments
(B) Methylate the synthesized DNA
(C) Introduce random point mutations purposefully
(D) Add a non-templated single adenine (A) residue to the 3' ends of the PCR product

2012

167. Which temperature defines the elongation phase catalyzed by Taq polymerase during a typical PCR cycle?
(A) $37^{\circ}C$
(B) $55^{\circ}C$
(C) $72^{\circ}C$
(D) $95^{\circ}C$

2022

168. The discovery of thermostable enzymes like Taq polymerase fundamentally revolutionized molecular biology by enabling:
(A) Automated thermal cycling without the need to add fresh enzyme every cycle
(B) The direct sequencing of entire genomes in a single day
(C) The synthesis of proteins inside the PCR machine
(D) The elimination of primers in DNA replication

2017

169. High-fidelity thermostable polymerases (e.g., Pfu) differ kinetically from Taq polymerase in that they generally:
(A) Synthesize DNA much faster
(B) Require significantly less magnesium
(C) Operate optimally at $37^{\circ}C$
(D) Have a slower extension rate due to active proofreading mechanisms

2001

170. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

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2007

262. The concept where an enzyme binds its substrate to restrict its motion and orient it for catalysis is known as:
(A) Entropy reduction (Entropy Trap)
(B) Enthalpy maximization
(C) Allosteric activation
(D) Metal ion activation

2015

263. Serine proteases, such as chymotrypsin, rely heavily on which localized catalytic structure?
(A) An iron-sulfur cluster
(B) The catalytic triad (Asp, His, Ser)
(C) A tightly bound PLP coenzyme
(D) Multiple zinc ions

2022

264. Which coenzyme is specifically required by enzymes that catalyze carboxylation reactions?
(A) Thiamine pyrophosphate
(B) Biotin
(C) Pyridoxal phosphate
(D) Lipoic acid

2010

265. Which international database provides comprehensive information on enzyme nomenclature, reactions, and properties?
(A) PubMed
(B) PDB
(C) BRENDA
(D) BLAST

2006

266. Which enzyme is commonly used to quantify glucose levels in clinical blood samples using a colorimetric assay?
(A) Hexokinase
(B) Glucose oxidase
(C) Glucokinase
(D) Amylase

2021

267. Which of the following is a key characteristic of the "transition state" in an enzymatic reaction?
(A) It is the most stable state of the system
(B) It can be isolated for structural analysis easily
(C) It is the configuration of atoms with the highest potential energy along the reaction path
(D) It corresponds to the enzyme-product complex

2006

268. Statins, used to lower cholesterol, are examples of transition-state analogs that inhibit which enzyme?
(A) HMG-CoA reductase
(B) Acetyl-CoA carboxylase
(C) Lipase
(D) Hexokinase

2001

269. In the catalytic triad of serine proteases, which amino acid residue acts as the nucleophile that attacks the peptide bond?
(A) Aspartate
(B) Histidine
(C) Serine
(D) Alanine

NODIA

2017

270. Zinc functions structurally in many DNA-binding proteins, but when it acts catalytically (e.g., in carboxypeptidase), it generally:
(A) Acts as an independent radical
(B) Denatures the protein core
(C) Stabilizes a developing negative charge in the transition state
(D) Transports oxygen

2009

271. Biotin, derived from Vitamin B_7, acts as a specialized coenzyme for which specific class of reactions?
(A) Decarboxylation
(B) Methylation
(C) Oxidation
(D) Carboxylation

2018

272. The Michaelis-Menten constant (K_m) is practically useful because it provides an estimate of:
(A) The total enzyme concentration inside the cell
(B) The rate of enzyme destruction
(C) The thermal stability of the active site
(D) The physiological intracellular concentration of the substrate

2007

273. At a substrate concentration mathematically equal to $2K_m$, the initial velocity of the reaction is:
(A) $0.5\,V_{\{}\max_{\}}$
(B) $0.67\,V_{\{}\max_{\}}$
(C) $0.75\,V_{\{}\max_{\}}$

into the enzyme's fundamental role in metabolic processes.

45. (A) Oxidoreductases
Alcohol dehydrogenase is assigned the EC number 1.1.1.1, where the initial digit signifies its membership in the oxidoreductase class. These enzymes are responsible for catalyzing oxidation-reduction reactions, which involve the transfer of electrons or hydrogen atoms between molecules. As the first enzyme listed in the classification system, alcohol dehydrogenase serves as a textbook example of essential redox chemistry in biological systems.

46. (C) Ligases
Enzymes classified under EC Class 6 are known as ligases, which are responsible for joining two molecules together to form a new chemical bond. This process is energetically demanding and is typically coupled with the hydrolysis of adenosine triphosphate or a similar nucleoside triphosphate. Ligases are essential for fundamental cellular processes, including DNA replication, repair, and various complex biosynthetic pathways within cells.

47. (D) Hydrolases
Hydrolases are a major class of enzymes that facilitate the breakdown of complex molecules by catalyzing the cleavage of covalent bonds through the addition of water. This class includes a diverse array of enzymes such as peptidases, esterases, and glycosidases. Their activity is fundamental to digestion and the recycling of cellular components, where they simplify larger structures into their basic subunits.

48. (C) They catalyze the movement of ions or molecules across membranes
Translocases, the most recently added major class (EC 7), are enzymes that catalyze the movement of ions or molecules across biological membranes. Many of these enzymes utilize energy from ATP hydrolysis to transport substrates against their concentration gradients. This classification recognizes the catalytic nature of membrane transport proteins, which are vital for maintaining cellular homeostasis and establishing essential electrochemical potentials and gradients.

49. (B) Lactate dehydrogenase
Lactate dehydrogenase is a classic example of an oxidoreductase, specifically a dehydrogenase that facilitates the interconversion of pyruvate and lactate. This reaction involves the transfer of electrons and hydride ions using NAD+ as a coenzyme. By managing these redox changes, the enzyme plays a central role in anaerobic glycolysis and the regeneration of NAD+ required for continued cellular energy production.

50. (A) IV, I, III, II
The major classes of enzymes are numerically ordered based on their reaction types: Class 1 consists of oxidoreductases, Class 2 includes transferases, Class 3 covers hydrolases, and Class 4 contains lyases. Following this systematic arrangement, the correct sequence starts with electron transfer and ends with group elimination. This hierarchy ensures a logical and standardized method for organizing the vast diversity.

51. (A) Transferases
Kinases are a major group of enzymes within the transferase class that specifically catalyze the transfer of a gamma-phosphate group from ATP to a substrate. This phosphorylation event is a key regulatory mechanism in cellular signaling, metabolism, and protein function. By modifying the charge and structure of their targets, kinases act as molecular switches that control a wide array of activities.

52. (C) Hydrolytic cleavage of specific chemical bonds
Hydrolases catalyze the breakdown of chemical bonds by introducing a water molecule, a process known as hydrolysis. This reaction type is used to degrade proteins, lipids, and carbohydrates into their constituent monomers. Because they do not require energy from ATP, hydrolases are often found in extracellular environments like the digestive tract, where they efficiently process dietary nutrients for subsequent cellular uptake.

53. (A) Lyases cleave bonds by eliminating groups to form double bonds or rings without adding water
Lyases are distinguished from hydrolases by their ability to cleave chemical bonds through mechanisms other than hydrolysis or oxidation. They typically remove functional groups to form double bonds or rings, or they add groups to existing double bonds. Unlike hydrolases, which rely on the addition of water, lyases function

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(B) Extreme acidity (pH 2-3)
(C) Freezing temperatures primarily
(D) Absolute lack of water

2013

285. In recombinant DNA technology, cloning vectors and insert DNA are typically digested with the same Type II restriction endonuclease to ensure:
(A) They possess perfectly compatible cohesive (or blunt) ends for ligation
(B) The DNA is fully degraded into individual nucleotides
(C) The host cell dies immediately upon transformation
(D) The vector changes its replication origin

2008

286. Restriction fragments generated with "sticky ends" are preferred in standard cloning primarily because:
(A) They ligate much less efficiently than blunt ends
(B) Their complementary overhangs hydrogen-bond, stabilizing the interaction for ligase
(C) They completely eliminate the need for ligase
(D) They automatically self-replicate without a vector

2009

287. Which component is strictly NOT necessary when setting up a typical PCR amplification reaction?
(A) Target DNA template
(B) Thermostable DNA polymerase
(C) Deoxynucleotide triphosphates (dNTPs)
(D) Reverse transcriptase

2010

288. In forensic DNA analysis, standard PCR utilizes thermostable polymerases primarily to amplify:
(A) Whole chromosomes in one piece
(B) Entire functional cell walls
(C) Ribosomal RNA directly
(D) Short tandem repeats (STRs) or specific loci

2022

289. What is a notable drawback of the native Taq DNA polymerase when amplifying very long DNA templates (>5 kb)?
(A) It acts as a strict helicase
(B) Its relatively high error rate can introduce unintended mutations
(C) It requires a completely different buffer pH
(D) It degrades RNA templates

2012

290. Abzymes mimic standard enzymes perfectly except they are fundamentally derived from:
(A) Myosins
(B) Keratins
(C) Histones
(D) Immunoglobulins

2019

291. The free energy of activation ($\Delta G^{\ddagger}$) represents the energy difference between:
(A) The reactant ground state and the transition state
(B) The reactant ground state and the product ground state
(C) The intermediate and the product
(D) The enzyme and the substrate before binding

NODIA

2004

292. In transition state stabilization, the enzyme actively forces the substrate into a geometry that most closely resembles the:
(A) Stable original substrate
(B) Final product
(C) High-energy transition intermediate
(D) Unreactive ground state

2022

293. The specific stereospecificity of enzymes arises because biological molecules (like amino acids and sugars) are inherently:
(A) Chiral
(B) Achiral
(C) Completely symmetric
(D) Inorganic

2010

294. The active site of an enzyme is usually a small part of the total volume because:
(A) The rest of the protein is junk DNA
(B) It minimizes the energy needed for translation
(C) The large protein scaffold is needed to orient functional groups precisely
(D) Small proteins are unstable in water

2016

295. Which of the following is an example of an enzyme that does not follow the one-protein, one-gene rule because it has multiple subunits?
(A) Myoglobin
(B) Lactate dehydrogenase
(C) Lysozyme
(D) Ribonuclease A

2010

296. Which enzyme is used in the ELISA technique to produce a detectable color change?

acids, their active sites are asymmetric and can only accommodate molecules with a specific spatial arrangement. This ensures that biological processes produce and utilize only the correct three-dimensional forms of sugars and amino acids.

27. (B) Group specificity
Hexokinase exhibits group specificity because it catalyzes the phosphorylation of a variety of six-carbon sugars, including glucose, fructose, and mannose. While the enzyme requires the general structural features of a hexose, it is not restricted to a single specific molecule. This type of specificity allows a single enzyme to function in the initial steps of different metabolic pathways involving related sugars.

28. (B) It binds substrates primarily through strong, permanent covalent bonds
The active site is a specialized three-dimensional pocket within an enzyme where the catalytic reaction occurs. While it determines specificity, the binding of substrates usually involves weak, reversible noncovalent interactions like hydrogen bonds and hydrophobic forces rather than permanent covalent bonds. These weak interactions allow for the rapid association and dissociation of molecules, which is essential for high catalytic turnover rates.

29. (A) Absolute specificity
Urease demonstrates absolute specificity because it catalyzes the hydrolysis of urea and shows no activity toward any other related chemical compounds. This extreme selectivity ensures that the enzyme performs only one highly specific task within the organism. Absolute specificity is common among enzymes that manage critical metabolic junctions where the processing of incorrect substrates could lead to toxic byproducts.

30. (A) P-2, Q-1, R-4, S-3
Enzymes display various levels of selectivity: urease shows absolute specificity for urea, while hexokinase acts on the general group of hexoses. L-amino acid oxidase distinguishes between optical isomers, demonstrating stereospecificity, and alpha-amylase targets specific linkages between sugar units. Understanding these different types of specificity is crucial for mastering how enzymes maintain the high precision and organization of cellular metabolism.

31. (D) A catalytically active complex of a protein and its coenzyme/cofactor
A holoenzyme refers to the complete, catalytically active form of an enzyme that includes both its protein component and any required non-protein cofactors. The presence of the cofactor is often essential for the enzyme to achieve the correct conformation or to participate directly in the chemical reaction. Without these additional components, the enzyme remains inactive and unable to facilitate biological processes.

32. (C) Apoenzyme
The protein component of an enzyme, when considered separately from its essential cofactors or coenzymes, is called an apoenzyme. In this state, the enzyme is generally catalytically inactive because it lacks the chemical groups provided by the non-protein partner. The association of the apoenzyme with its specific cofactor results in the formation of the active holoenzyme capable of driving metabolic reactions.

33. (B) Prosthetic group
A prosthetic group is a non-protein molecule that is tightly or even covalently attached to an enzyme's structure. Unlike co-substrates that associate and dissociate during the reaction cycle, prosthetic groups remain permanently bound to the apoenzyme. They are vital for the catalytic mechanism, often participating in electron transfer or group stabilization, and are regenerated in situ after each turnover cycle.

34. (D) Co-substrates loosely bind and dissociate from the enzyme during the reaction
Co-substrates are organic cofactors that bind loosely to an enzyme and are chemically modified during the reaction. Unlike prosthetic groups, which remain permanently attached, co-substrates dissociate from the enzyme to be regenerated by a different enzymatic reaction elsewhere. This reversible binding allows co-substrates to function as carriers of chemical groups or electrons between various metabolic pathways within the cell.

35. (A) Holoenzyme − Coenzyme = Apoenzyme
An active holoenzyme is the functional unit consisting of a protein apoenzyme and its necessary non-protein cofactors or coenzymes. Mathematically and structurally, removing the coenzyme from the holoenzyme leaves behind the inactive apoenzyme. This relationship

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ANSWERS

1. (B) An RNA molecule capable of acting as an enzyme
Ribozymes are specialized RNA molecules possessing catalytic activity, challenging the historical view that all biological catalysts are proteins. These nucleic acids facilitate crucial reactions such as RNA splicing and peptide bond formation within ribosomes. Their structure allows for specific folding, creating active sites that interact with substrates to accelerate biochemical processes efficiently under physiological conditions throughout the cell.

2. (D) They can be engineered to catalyze reactions for which no natural enzyme exists
Abzymes, or catalytic antibodies, are designed to bind transition-state analogs of specific reactions. This allows researchers to create catalysts for chemical transformations that do not occur via natural enzymatic pathways. By utilizing the immune system's vast diversity, scientists develop tailored biocatalysts capable of performing highly specialized industrial or therapeutic reactions with extreme specificity and efficiency in various environments.

3. (A) They increase reaction rates without undergoing permanent chemical change
Biocatalysts function by providing an alternative reaction pathway that significantly lowers the activation energy required for a chemical transformation. While they interact directly with substrates, they emerge from the catalytic cycle chemically unchanged. This property allows a single enzyme molecule to process numerous substrate molecules repeatedly, enhancing the speed of metabolic reactions without being consumed or permanently altered during catalysis.

4. (C) It leaves the overall Gibbs free energy change unaffected
Enzymes accelerate biochemical reactions by lowering the activation energy barrier, but they do not change the thermodynamic stability of reactants or products. Consequently, the overall Gibbs free energy change remains constant. Because enzymes do not alter the starting or final energy levels, they cannot change the equilibrium position or make a non-spontaneous reaction spontaneous within a biological system.

5. (A) Enzymes are exclusively proteinaceous in nature
The identification of catalytic RNA, known as ribozymes, fundamentally shifted the biological paradigm that all enzymes are composed of proteins. This discovery proved that nucleic acids can possess complex tertiary structures necessary for catalysis. It supports the RNA world hypothesis, suggesting that RNA preceded DNA and proteins as both the primary genetic material and the catalyst in early life.

6. (D) They are synthesized by ribosomes for metabolism
Catalytic antibodies are typically generated by the immune system in response to synthetic transition-state analogs rather than being standard products of metabolic gene expression for primary metabolism. Unlike traditional enzymes encoded by the genome for specific cellular roles, abzymes are engineered tools produced through monoclonal antibody technology to facilitate specific chemical reactions not natively performed by the living cell.

7. (B) It cleaves precursor tRNA to generate mature tRNA
Ribonuclease P is a ubiquitous ribozyme found in all living organisms that performs the essential processing of precursor transfer RNA. It functions by catalyzing the hydrolytic cleavage of the five-prime leader sequence, resulting in mature tRNA molecules ready for protein synthesis. This catalytic event demonstrates the vital role of RNA-based enzymes in fundamental genetic information processing within the cytoplasm.

8. (C) The RNA world hypothesis where RNA served as both genetic and catalytic material
The RNA world hypothesis proposes that early life forms relied on RNA to store genetic information and catalyze essential biochemical reactions. During this evolutionary stage, ribozymes were the primary biocatalysts before the emergence of more efficient protein enzymes. This highlights the versatile nature of RNA

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(A) DNA polymerase
(B) Restriction enzyme
(C) Horseradish peroxidase
(D) RNA polymerase

2018

297. Which of the following is a classic example of an irreversible inhibitor used as an insecticide?
(A) Penicillin
(B) Malathion
(C) Aspirin
(D) Methotrexate

2025

298. General base catalysis requires an amino acid residue to act as a:
(A) Proton acceptor
(B) Proton donor
(C) Covalent nucleophile
(D) Metal chelator

2007

299. Coenzyme A is a critical molecule built from which specific vitamin?
(A) Riboflavin
(B) Pantothenic acid
(C) Niacin
(D) Thiamine

2013

300. In a clinical setting, severe liver damage (hepatitis) is most prominently indicated by sharp elevations in serum:
(A) CPK-MB and Troponin
(B) ALT (SGPT) and AST (SGOT)
(C) Amylase and Lipase
(D) Acid phosphatase

****

NODIA

by which enzymes achieve their remarkable catalytic power.

18. (D) By lowering the free energy of the transition state
Enzymes accelerate reactions by specifically binding and stabilizing the high-energy transition state, which is the most unstable point on the reaction coordinate. By lowering the free energy of this state, the energy barrier that reactants must overcome is reduced. This stabilization ensures that the transition state is reached more frequently, allowing the reaction to proceed rapidly under mild cellular conditions.

19. (A) Coupling it with a highly exergonic reaction, such as ATP hydrolysis
Endergonic reactions, which require a net input of free energy, cannot proceed spontaneously in isolation. Cells overcome this thermodynamic hurdle by coupling these unfavorable processes with highly exergonic reactions, typically the hydrolysis of adenosine triphosphate. The overall free energy change for the coupled reactions becomes negative, allowing the synthesis of complex molecules and the maintenance of essential biological gradients.

20. (A) Both A and R are true and R is the correct explanation of A.
Enzymes act as catalysts that increase the rate of chemical reactions without being consumed or altering the final equilibrium. They achieve this by specifically lowering the activation energy required to reach the transition state. Since they do not change the initial energy of reactants or the final energy of products, the overall standard Gibbs free energy change remains completely unaffected.

21. (A) Entropy (ΔS)
Entropy is the thermodynamic variable that quantifies the degree of disorder or randomness within a physical or chemical system. In biological reactions, changes in entropy often result from the organization of water molecules or the breakdown of large polymers into smaller components. Understanding entropy is essential for determining the overall spontaneity of metabolic processes as part of the Gibbs free energy.

22. (D) It has the highest free energy along the reaction coordinate
The transition state represents a brief, high-energy moment during a chemical reaction where bonds are being formed or broken. It is the most unstable point along the reaction coordinate and possesses the maximum free energy. Because of its extreme instability and fleeting nature, the transition state cannot be isolated, and molecules must overcome this energy barrier to transform into products.

23. (B) The rate is inversely and exponentially related to activation energy
The relationship between the rate of a chemical reaction and its activation energy is described by the Arrhenius equation. This mathematical model shows that the reaction rate constant increases exponentially as the activation energy decreases. Consequently, even a small reduction in the energy barrier provided by an enzyme leads to a massive, non-linear increase in the speed of the biochemical reaction.

24. (C) The enzyme's active site is perfectly complementary to the transition state
The efficiency of enzyme catalysis stems from the active site being structurally and energetically complementary to the transition state rather than the substrate itself. This optimized fit allows for the maximum number of weak interactions to form precisely when the molecule is in its high-energy state. These interactions release binding energy that offsets the energy required to reach the transition barrier.

25. (D) The activation energy barrier increases, impeding the reaction
If an enzyme's active site were perfectly complementary to the stable substrate, the resulting enzyme-substrate complex would be significantly stabilized, effectively falling into an energy well. This would increase the total activation energy required to reach the transition state, making the reaction harder to proceed. Efficient catalysis requires that the most favorable interactions occur only when the substrate reaches the transition state.

26. (A) Stereospecificity
Stereospecificity is a hallmark of enzyme action where a catalyst distinguishes between different optical or geometric isomers of a substrate. Because enzymes are composed of chiral amino

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molecules, which can fold into complex shapes to facilitate diverse, vital chemical transformations efficiently.

9. (D) A ribozyme
Peptidyl transferase is the fundamental catalytic component of the large ribosomal subunit responsible for creating peptide bonds during protein synthesis. Structural studies have confirmed that this activity is driven by ribosomal RNA rather than ribosomal proteins, classifying it as a ribozyme. This discovery emphasizes the central role of catalytic RNA in the most conserved and essential biological processes.

10. (C) I and III
Abzymes are created using transition-state analogs to mimic the high-energy intermediate of a reaction, while enzymes function by lowering activation energy barriers. However, not all ribozymes require proteins for catalysis, as many possess intrinsic catalytic activity based solely on their RNA structure. Combining these facts confirms that catalytic antibodies and activation energy reduction are core principles of modern biocatalysis.

11. (B) It is perfectly equal to zero
When a biochemical system reaches chemical equilibrium, the rate of the forward reaction perfectly balances the rate of the reverse reaction. At this point, there is no net change in the concentration of reactants or products, meaning the actual change in Gibbs free energy is exactly zero. This state represents the minimum energy configuration for the given chemical system.

12. (B) Spontaneous and exergonic
A negative change in Gibbs free energy characterizes a reaction that is thermodynamically favorable and spontaneous in the forward direction. Such reactions are termed exergonic because they involve a net release of free energy. While this value indicates the potential for a reaction to occur without external energy input, it does not provide information regarding the actual reaction rate.

13. (A) Gibbs free energy change
The direction in which a chemical reaction proceeds is determined by the sign of the Gibbs free energy change. A negative value indicates a spontaneous forward reaction, while a positive value necessitates energy input to drive the process. While activation energy determines the speed, the free energy difference between reactants and products defines the ultimate thermodynamic feasibility and direction.

14. (C) The equilibrium point remains completely unchanged
Enzymes function by accelerating both the forward and reverse reaction rates equally, allowing the system to reach equilibrium faster. However, they do not alter the relative concentrations of reactants and products at the equilibrium point. Because the equilibrium constant is determined solely by the thermodynamic properties of the substances involved, the presence of a catalyst leaves this final state unaffected.

NODIA

15. (D) $\Delta G^{\circ} = -RT\ln K_{eq}$
The relationship between the standard free energy change and the equilibrium constant is mathematically defined by the logarithmic equation involving the gas constant and temperature. A large equilibrium constant reflects a more negative standard free energy change, indicating a spontaneous reaction under standard conditions. This fundamental equation allows biochemists to calculate the energy potential of metabolic reactions from measured equilibrium concentrations.

16. (C) Enzymes provide an alternative reaction pathway with lower activation energy
Enzymes facilitate chemical transformations by stabilizing the transition state, thereby providing an alternative reaction coordinate with a significantly lower activation energy. This allows a greater fraction of molecules to possess sufficient energy to react at physiological temperatures. Crucially, the catalyst does not alter the energy levels of the ground-state reactants or the final products, maintaining consistent overall reaction thermodynamics.

17. (B) Weak noncovalent interactions between enzyme and substrate
Binding energy is the free energy released when an enzyme forms multiple weak, noncovalent interactions with its substrate. These interactions, including hydrogen bonds, ionic interactions, and van der Waals forces, provide the driving force for lowering the activation energy. The maximization of these interactions specifically in the transition state is the primary mechanism

highlights the dependency of many enzymes on small organic molecules or metal ions to perform their specific catalytic duties within complex biological and metabolic systems.

36. (C) They freely diffuse through the cytoplasm between distinct reactions
Prosthetic groups are permanent structural components of their respective enzymes and do not freely diffuse through the cytoplasm between different reactions. Instead, they remain sequestered within the enzyme's active site throughout the catalytic cycle. While they may undergo chemical changes during a reaction, they are always restored to their original state before the enzyme can process a new substrate molecule.

37. (A) Tightly bound prosthetic group
Flavin adenine dinucleotide is a vital redox cofactor that is typically bound very tightly, often covalently, to its apoenzyme. Because it does not dissociate during the catalytic process, it is classified as a prosthetic group. FAD facilitates the transfer of electrons in various metabolic pathways, such as the citric acid cycle and the electron transport chain, while remaining permanently attached.

38. (D) Co-substrate
Nicotinamide adenine dinulin nucleotide functions as a versatile electron carrier in dehydrogenase reactions. It acts as a co-substrate because it binds to the enzyme, accepts a hydride ion to become NADH, and then dissociates to be regenerated by other cellular processes. This ability to move between different enzymes allows NAD+ to effectively link the oxidative and reductive phases of cellular metabolism.

39. (B) Coenzyme A (CoA)
Coenzyme A is a critical metabolic carrier that functions as a co-substrate by transporting acyl groups between different chemical reactions. It binds transiently to enzymes, receives an acyl group via a high-energy thioester bond, and then moves to another enzyme to deliver the group. This mechanism is central to lipid metabolism and the entry of carbon units into the cycle.

40. (C) Class → Subclass → Sub-subclass → Serial number
The International Union of Biochemistry and Molecular Biology developed a systematic four-digit classification system to organize enzymes based on the reactions they catalyze. The first digit identifies the major class, followed by the subclass and sub-subclass, which provide increasingly specific details about the mechanism and substrates. The final digit is a unique serial number assigned to each individual enzyme recognized.

41. (C) Four
Every enzyme recognized by the Enzyme Commission is assigned a unique EC number consisting of four digits separated by periods. These digits represent a hierarchical classification system that describes the enzyme's general reaction type, the nature of the chemical group being transformed, and specific details of the reaction. This standardized nomenclature allows for clear communication among scientists regarding enzymatic functions across species.

42. (A) Hydrolases
In the systematic Enzyme Commission classification, Class 3 is reserved for hydrolases. These enzymes facilitate the cleavage of various chemical bonds, such as ester, ether, peptide, or glycosidic bonds, by the addition of a water molecule. Common examples include digestive enzymes like lipases and proteases, which break down complex nutrients into simpler components that the body can readily absorb and utilize.

43. (B) Class 2: Transferases
Transferases are enzymes that catalyze the relocation of functional groups, such as methyl, acyl, or phosphate groups, from one substrate molecule to another. By moving these groups, transferases play a vital role in signaling, biosynthetic pathways, and energy metabolism. Kinases, a well-known subclass, are specifically involved in the transfer of phosphate groups from ATP to various target molecules within cells.

44. (B) The major class of the enzyme based on the reaction type
The first digit of an EC number categorizes the enzyme into one of the seven major classes defined by the International Union of Biochemistry and Molecular Biology. This number is assigned based on the general type of chemical reaction the enzyme facilitates, such as oxidation-reduction or hydrolysis. This high-level classification provides immediate insight

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(D) $1.0\,V_{\{max\}}$

2017

274. In a Lineweaver-Burk plot, a competitive inhibitor fundamentally causes:
(A) Both intercepts to shift
(B) Only the y-intercept to shift upwards
(C) The line to become perfectly horizontal
(D) The x-intercept to move closer to zero, while the y-intercept remains constant

2008

275. Uncompetitive inhibitors are most effective under which condition?
(A) At very high substrate concentrations, because the ES complex is abundant
(B) At very low substrate concentrations
(C) When the enzyme is mostly free
(D) When the temperature is sub-optimal

2005

276. Suicide inhibitors (mechanism-based inactivators) are highly prized in pharmacology because they:
(A) Cause widespread systemic toxicity
(B) Bind loosely and can be washed out
(C) Exhibit extreme specificity, generally only targeting the specific enzyme that attempts to process them
(D) Do not possess any chemical structure

2009

277. The sigmoidal velocity curve of an allosteric enzyme fundamentally implies:
(A) Cooperative interactions among multiple active sites
(B) Irreversible inactivation at high substrate concentrations
(C) The enzyme operates strictly via a single monomeric unit
(D) Michaelis-Menten kinetics are perfectly obeyed

2013

278. Reversible covalent modifications such as phosphorylation are energetically economical for the cell because:
(A) The phosphate group is generated without ATP
(B) They fundamentally change the primary sequence
(C) They require no regulatory oversight
(D) The enzyme does not need to be degraded and re-synthesized from scratch

2009

279. An important distinction between isoenzymes is that they:
(A) Catalyze exactly the same chemical reaction but usually possess different kinetic parameters
(B) Catalyze completely different chemical reactions using the same substrate
(C) Function universally in identical cellular compartments
(D) Are simply misfolded versions of the same protein

2013

280. Measuring serum levels of the CPK-MB isoenzyme is critical in the acute diagnosis of:
(A) Pancreatic failure
(B) Liver cirrhosis
(C) Acute myocardial infarction
(D) Bone cancer

2009

281. The immobilization of an enzyme onto a solid non-porous support surface relies heavily on:
(A) Entrapment
(B) Microencapsulation
(C) Dissolution in organic solvents
(D) Adsorption or covalent attachment

2017

282. The mass transfer resistance often observed in immobilized enzymes implies that:
(A) Substrate molecules struggle to diffuse rapidly to the active site
(B) The enzyme freely diffuses away into the medium
(C) The products are immediately completely destroyed
(D) The enzyme loses its entire molecular mass

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2016

283. High-fructose corn syrup is commercially produced using a sequential multi-enzyme process. Which enzyme is responsible for the final conversion step?
(A) Alpha-amylase
(B) Glucoamylase
(C) Glucose isomerase
(D) Pullulanase

2002

284. Which environmental challenge must alkaline proteases added to modern laundry detergents successfully withstand?
(A) The presence of bleach, high pH, and surfactants

through group elimination or addition, often creating structural changes within the substrate.

54. (D) Lyase
Fumarase is classified as a lyase because it catalyzes the reversible hydration of fumarate to form malate. Although water is involved, the enzyme functions by adding a water molecule across the carbon-carbon double bond of fumarate rather than using it to cleave a bond. This reaction is a critical step in the citric acid cycle, facilitating the regeneration of oxaloacetate for energy.

55. (B) Isomerases
Epimerases and racemases are specific types of isomerases that catalyze the interconversion of optical or geometric isomers. They function by changing the stereochemistry at a single chiral center within a molecule. These enzymes are vital in carbohydrate and amino acid metabolism, ensuring that the cell has the specific three-dimensional forms of molecules required for protein synthesis and various other biosynthetic pathways.

56. (C) EC 6
DNA ligase belongs to the EC Class 6, which encompasses all ligases. These enzymes are responsible for joining DNA strands together by catalyzing the formation of a phosphodieser bond. Because this process involves the synthesis of a new covalent bond between two large molecules, it requires the hydrolysis of ATP or NAD+ to provide the necessary thermodynamic driving force for the specific reaction.

57. (D) Translocases
Translocases were officially designated as EC Class 7 to represent enzymes that facilitate the movement of ions or molecules across biological membranes. This addition acknowledges that many membrane transporters exhibit catalytic activity by coupling transport with chemical reactions, such as ATP hydrolysis. The classification provides a dedicated space for these essential proteins, which maintain the concentration gradients necessary for cellular life and homeostasis.

58. (A) Isomerases
Mutases are specialized isomerases that catalyze the intramolecular movement of a functional group, such as a phosphate or methyl group, from one position to another within the same molecule. These enzymes facilitate structural rearrangements that prepare substrates for subsequent metabolic steps. A well-known example is phosphoglycerate mutase, which shifts a phosphate group during glycolysis to optimize the molecule for further energy extraction.

59. (D) Ligases
The term synthetase is specifically applied to enzymes that join two molecules using the energy derived from the hydrolysis of a nucleoside triphosphate, placing them in the ligase class. In contrast, synthases do not require high-energy phosphate bonds and are typically classified as lyases or transferases. This distinction is critical for understanding the energetic requirements and mechanisms of various biosynthetic enzymes.

60. (D) I, II, III and IV
Each major enzyme class possesses unique catalytic features: hydrolases use water to break bonds, while lyases form double bonds by removing groups. Isomerases manage internal structural rearrangements, and ligases couple bond formation with ATP hydrolysis. Together, these statements accurately summarize the fundamental reaction mechanisms that define the systematic classification of enzymes, reflecting the diverse chemical strategies employed by biological catalysts within cells.

61. (A) Emil Fischer
The "Lock-and-Key" model of enzyme action was originally proposed by Emil Fischer in 1894 to explain the remarkable specificity of biocatalysts. He suggested that the enzyme and substrate possess rigid, complementary shapes that fit together perfectly, much like a key fits into a specific lock. While later refined, this foundational concept introduced the idea that molecular shape is paramount for biological function.

62. (C) The active site is completely complementary to the substrate prior to binding
The fundamental assumption of the lock-and-key hypothesis is that the active site of an enzyme is a pre-formed, rigid structure. It assumes that the substrate's shape perfectly matches the active site's geometry even before any interaction occurs. This model emphasizes structural rigidity and absolute complementarity, suggesting that only a substrate with the exact

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conditions, where they catalyze the reduction of pyruvate to lactate to regenerate the NAD+ needed for glycolysis. This allows the muscle to continue producing energy during intense physical activity when oxygen levels are temporarily insufficient for respiration.

135. (B) CPK-MB
Creatine phosphokinase exists as a dimeric enzyme with two subunit types, M and B. The CPK-MB isoenzyme is found almost exclusively in heart tissue, making it an invaluable diagnostic tool for clinicians. Following a myocardial infarction, damaged heart cells leak this specific isoenzyme into the bloodstream, where its elevated levels can be used to confirm the diagnosis and assess the extent of damage.

136. (C) Liver
Alanine Aminotransferase, also known as SGPT, is an enzyme primarily localized within the cytoplasm of liver cells. When hepatocytes are damaged or destroyed due to infection, toxins, or inflammation, ALT leaks into the systemic circulation. Therefore, measuring elevated serum levels of this enzyme is one of the most specific and sensitive tests used to identify and monitor various forms of liver disease.

137. (D) Biliary obstruction and bone disorders
Alkaline Phosphatase is a versatile enzyme found in several tissues, but its highest concentrations are in the liver and bone. Significantly elevated serum levels of ALP are most strongly associated with biliary obstruction, such as gallstones, or with increased bone turnover, as seen in Paget's disease or growing children. Clinical differentiation between these sources is often achieved by analyzing specific ALP patterns.

138. (A) Leak into the systemic circulation following cellular injury or necrosis
Diagnostic enzymology is based on the principle that intracellular enzymes are normally sequestered within specific compartments of the cell. When cellular injury or necrosis occurs, the integrity of the cell membrane is compromised, allowing these enzymes to leak into the bloodstream. By measuring the concentration and type of enzymes present in the serum, clinicians can pinpoint the site and severity of tissue damage.

139. (A) Heart
Aspartate Aminotransferase, also referred to as SGOT, is distributed in various tissues but is found in particularly high concentrations in the liver and the heart muscle. While it is less specific for liver damage than ALT, its elevated presence in the serum is a key indicator of cardiac or hepatic injury. AST levels are often measured alongside other enzymes for diagnostics.

140. (A) P-3, Q-1, R-4, S-2
Different serum enzymes serve as markers for specific pathologies: CPK-MB indicates heart damage, while ALT is a hallmark of liver parenchymal injury. Alkaline phosphatase levels rise during obstructive jaundice, and elevated amylase is a classic sign of acute pancreatitis. This systematic use of enzyme profiling allows healthcare providers to accurately diagnose organ-specific conditions and monitor the patient's recovery process over time.

141. (A) Restrict enzyme mobility, allowing for reuse and continuous operation
Enzyme immobilization is a critical bioprocessing technique where enzymes are physically or chemically confined to a specific space or support matrix. The primary goal is to restrict the enzyme's mobility, which allows the catalyst to be easily recovered and reused in multiple reaction cycles. This significantly reduces the cost of industrial processes and enables continuous operation in large-scale bioreactors for consistent production.

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142. (B) Entrapment
The entrapment method of enzyme immobilization involves physically trapping enzyme molecules within the pores of a polymer matrix or semi-permeable membrane. Common matrices include calcium alginate and polyacrylamide gels, which allow substrate and product molecules to diffuse freely while keeping the large enzyme sequestered. This technique is relatively gentle and helps protect the enzyme from harsh external environmental conditions during industrial reactions.

143. (D) Amino groups of lysine or sulfhydryl groups of cysteine
Immobilization by covalent binding involves the formation of stable chemical bonds between functional groups on the enzyme surface and the support matrix. The most commonly utilized

then attack substrates like carbon dioxide or peptide bonds. By lowering the pKa of water...

72. (C) Zinc ($Zn^{\{2+\}}$)
Carbonic anhydrase is a critical enzyme that requires a tightly bound zinc ion for its catalytic activity. The metal ion plays a direct role in the mechanism by coordinating with a water molecule and activating it for nucleophilic attack on carbon dioxide. This process allows the enzyme to achieve some of the highest known turnover rates, facilitating rapid gas exchange in the blood.

73. (D) An enzyme containing tightly bound metal ions essential for activity
A metalloenzyme is a specialized protein that contains one or more metal ions tightly bound to its structure, which are essential for its catalytic activity. These ions often participate directly in the reaction mechanism or stabilize the protein's tertiary structure. Unlike metal-activated enzymes that only loosely associate with ions, metalloenzymes retain their metal components throughout the processes of isolation and purification.

74. (A) ATP
Magnesium ions are essential cofactors for nearly all enzymes that utilize adenosine triphosphate as a substrate. The metal ion binds to the negatively charged phosphate groups of ATP, forming a stable Mg-ATP complex that fits correctly into the enzyme's active site. By neutralizing the negative charges, magnesium facilitates the nucleophilic attack on the phosphate bonds, which is necessary for energy transfer.

75. (D) Iron and Copper
Iron and copper are the primary transition metals used by enzymes to facilitate redox reactions due to their ability to exist in multiple stable oxidation states. These metals can easily gain or lose electrons, making them ideal for carrying charges in the electron transport chain or during cellular respiration. Their versatile electronic properties allow for the precise management of high-energy electrons.

76. (B) Copper and Iron
Cytochrome oxidase, the final complex in the mitochondrial electron transport chain, relies on both iron and copper ions to function. The iron is contained within heme groups, while the copper ions facilitate the transfer of electrons to oxygen, the terminal electron acceptor. Together, these metal centers ensure the efficient reduction of oxygen to water, which is coupled with the production of ATP.

77. (A) Vitamin B_1
Thiamine pyrophosphate is the active coenzyme form of vitamin B_1, also known as thiamine. It is essential for enzymes that catalyze the decarboxylation of alpha-keto acids, such as pyruvate dehydrogenase. The thiazolium ring of TPP provides a stable carbanion that can attack the substrate, facilitating the cleavage of carbon-carbon bonds. A deficiency in this vitamin leads to serious metabolic disorders.

78. (C) Transamination of amino acids
Pyridoxal phosphate is a versatile coenzyme derived from vitamin B_6 that is absolutely critical for amino acid metabolism. It primarily facilitates transamination reactions, where an amino group is transferred from an amino acid to a keto acid. PLP functions by forming a Schiff base intermediate with the substrate, stabilizing the transition state and allowing for various transformations like deamination and deamination.

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79. (A) Niacin
The coenzymes nicotinamide adenine dinucleotide and its phosphorylated form are derived from the vitamin niacin, also known as vitamin B_3. These molecules are indispensable electron carriers that participate in hundreds of oxidation-reduction reactions across all metabolic pathways. By accepting or donating hydride ions, they facilitate the energy-yielding breakdown of nutrients and provide the reducing power required for complex biosynthetic reactions.

80. (A) Both A and R are true and R is the correct explanation of A.
Coenzyme A is the primary carrier of acyl groups in metabolism, facilitating reactions like fatty acid oxidation and the citric acid cycle. Its functional importance stems from a reactive terminal sulfhydryl group that forms a high-energy thioester bond with acyl fragments. This bond is thermodynamically unstable, making the acyl group highly reactive and easily transferable to other molecules during enzymatic catalysis.

corresponding shape can enter and undergo a catalytic transformation.

63. (D) Induced-fit hypothesis
The induced-fit hypothesis proposes that the enzyme's active site is not a rigid template but a flexible structure. According to this model, the initial binding of the substrate triggers a conformational change that brings catalytic groups into the precise orientation required for the reaction. This flexibility allows the enzyme to achieve optimal complementarity with the transition state, enhancing its overall catalytic efficiency.

64. (C) The induced-fit hypothesis
Daniel Koshland formulated the induced-fit hypothesis in 1958, challenging the older lock-and-key model. He argued that enzymes are dynamic molecules that undergo structural shifts upon substrate binding to facilitate catalysis. This model better accounts for the observation that some enzymes can bind multiple related substrates and provides a more accurate description of the energetic interactions that stabilize the high-energy transition state.

65. (B) Broad group specificity and the prevention of non-productive reactions
The induced-fit model offers a superior explanation for how enzymes exhibit broad group specificity while still preventing non-productive reactions, such as the accidental hydrolysis of ATP. By requiring a specific conformational change, the enzyme ensures that the catalytic machinery is only activated when the correct substrate is properly positioned. This dynamic matching is essential for maintaining high fidelity and control.

66. (D) By donating or accepting protons to stabilize the transition state
General acid-base catalysis accelerates reactions through the strategic donation or acceptance of protons by amino acid side chains within the active site. These proton transfers stabilize developing charges in the transition state, making it easier for the reaction to proceed. This mechanism is particularly effective in biological systems where pH is tightly regulated and water alone may not be a sufficiently fast catalyst.

67. (A) Histidine
Histidine is the most versatile amino acid in general acid-base catalysis because its side chain has a pKa near physiological pH. This unique property allows the imidazole group to act as either a proton donor or a proton acceptor depending on the local environment. Consequently, histidine is frequently found in the active sites of many enzymes, participating in various essential proton shuffling steps.

68. (C) Nucleophilic functional group on the enzyme
Covalent catalysis involves the formation of a transient, high-energy covalent bond between the substrate and a nucleophilic functional group on the enzyme. This intermediate provides a new reaction pathway that lowers the activation energy for subsequent steps. Common nucleophiles include the hydroxyl group of serine or the sulfhydryl group of cysteine, which must be regenerated to their original state to complete the cycle.

69. (A) Proximity and orientation effects
Catalysis via proximity and orientation effects occurs when an enzyme binds two or more substrates in a way that brings their reactive groups into close contact and correct spatial alignment. By restricting the motion of the reactants, the enzyme significantly increases the effective concentration and collision frequency. This reduction in translational and rotational entropy makes the formation of the transition state more probable.

70. (A) I, II and V
Efficient catalysis relies on several coordinated strategies: electrostatic interactions stabilize transition state charges, while covalent catalysis utilizes enzyme-based nucleophiles. Histidine serves as a flexible acid-base catalyst due to its favorable pKa value. In contrast, proximity effects actually increase the effective concentration of reactants, and general acid-base catalysis often utilizes amino acid side chains rather than relying exclusively on water molecules.

71. (B) Polarizing water to generate a highly nucleophilic hydroxide ion
In many enzymes, zinc ions function by coordinating with a water molecule and polarizing it to facilitate the loss of a proton. This process generates a highly nucleophilic hydroxide ion at physiological pH, which can

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90. (A) P-2, Q-1, R-4, S-3
Different graphical methods are used to linearize enzyme kinetic data: the Lineweaver-Burk plot uses double reciprocals, while the Eadie-Hofstee plot maps velocity against the velocity-to-substrate ratio. The Hanes-Woolf plot utilizes the ratio of substrate to velocity, and the standard Michaelis-Menten curve is a non-linear hyperbola. Each plot offers distinct advantages for visualizing data and identifying different types of inhibition.

91. (B) $\frac{1}{V_{\max}}$
In a Lineweaver-Burk double reciprocal plot, the y-intercept is mathematically defined as the reciprocal of the maximal velocity. By extending the linear regression line to cross the vertical axis, researchers can accurately determine the $V_{\{}\max_{\}}$ of an enzyme-catalyzed reaction. This graphical approach is particularly useful for comparing how various inhibitors affect the maximum catalytic rate without needing high substrate concentrations.

92. (A) $-\frac{1}{K_m}$
The x-intercept of a Lineweaver-Burk plot represents the negative reciprocal of the Michaelis constant. Finding where the line crosses the horizontal axis allows for the direct determination of K_m, which reflects the enzyme's affinity for its substrate. This value is critical for understanding metabolic regulation and the impact of competitive inhibitors, which shift this intercept without changing the maximal velocity.

93. (A) It does not compress data at high substrate concentrations, minimizing error distortion
The Eadie-Hofstee plot is often preferred over the Lineweaver-Burk plot because it provides a more even distribution of data points across its axes. While the double reciprocal plot tends to compress data at high substrate concentrations, potentially magnifying experimental errors, the Eadie-Hofstee method maintains consistent weighting. This results in more reliable estimates of kinetic parameters, especially with data containing noise.

94. (C) $\frac{1}{V_{\max}}$
In a Hanes-Woolf plot, where the ratio of substrate concentration to velocity is plotted against the substrate concentration, the resulting line has a slope equal to the reciprocal of $V_{\{}\max_{\}}$. This linear transformation allows for the precise determination of the maximal reaction rate. Additionally, the x-intercept of this plot gives the negative value of K_m, providing both fundamental kinetic constants.

95. (D) $k_{\{cat\}}$
The turnover number, denoted as $k_{\{cat\}}$, is a fundamental kinetic constant that represents the number of substrate molecules converted to product by a single enzyme active site per unit time when the enzyme is fully saturated. It is calculated by dividing the maximal velocity by the total enzyme concentration. This value allows for a direct comparison of the catalytic power of different.

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96. (C) The number of substrate molecules converted to product per enzyme molecule per unit time, under saturating conditions
The turnover number provides a measure of how efficiently an enzyme converts substrate into product once the enzyme-substrate complex has formed. Under saturating conditions, $k_{\{cat\}}$ represents the maximum number of chemical transformations occurring at each active site every second. High $k_{\{cat\}}$ values indicate very fast enzymes, such as carbonic anhydrase, which can process hundreds of thousands of molecules in one second.

97. (B) Catalytic efficiency and specificity
The ratio of the turnover number to the Michaelis constant, known as the specificity constant, is the ultimate measure of an enzyme's catalytic efficiency. It accounts for both the speed of the chemical reaction and the strength of substrate binding. This value is particularly useful for comparing an enzyme's preference for different substrates, especially when the substrate concentrations are far below saturation.

98. (D) Catalytic perfection, limited only by diffusion
When an enzyme's specificity constant reaches values between ten to the eighth and ten to the ninth per molar per second, it is considered catalytically perfect. At this point, the reaction rate is no longer limited by the enzyme's chemistry but by the speed at which substrate molecules can diffuse through the solvent to the active site. Such enzymes represent evolutionary optimization.

81. (B) Vitamin B_2 (Riboflavin)
Flavin adenine dinucleotide and flavin mononucleotide are both derived from riboflavin, which is vitamin B_2. These coenzymes act as essential prosthetic groups in many oxidoreductases, particularly those involved in the mitochondrial electron transport chain and the citric acid cycle. The isoalloxazine ring of the flavin molecule can undergo two-electron reduction, allowing these enzymes to participate in various vital processes.

82. (D) One-carbon group transfer
Tetrahydrofolate is a critical coenzyme derived from the vitamin folic acid that specializes in the transport of one-carbon units. These units, which include methyl, methylene, and formyl groups, are essential for the synthesis of purines, thymidine, and certain amino acids. By acting as a versatile donor and acceptor of single carbons, THF supports the rapid DNA replication and cell division processes.

83. (A) The rate of ES complex formation equals the rate of its breakdown
The derivation of the Michaelis-Menten equation relies on the steady-state assumption, which posits that the concentration of the enzyme-substrate complex remains constant over time. This occurs when the rate of formation of the complex is exactly balanced by the rate of its breakdown into products or back into reactants. This simplification allows for a manageable mathematical description of enzymatic kinetics.

84. (C) The enzyme is completely saturated with substrate
The maximal velocity of an enzyme-catalyzed reaction represents the theoretical limit of the reaction rate when the enzyme is completely saturated with substrate. At this point, every available active site is occupied by a substrate molecule, and the reaction follows zero-order kinetics. $V_{\{}\max_{\}}$ is directly proportional to the total concentration of the enzyme and provides a measure of its maximum catalytic capacity.

85. (A) The substrate concentration at which the reaction velocity is half of $V_{\{}\max_{\}}$
The Michaelis constant is defined as the specific substrate concentration at which the reaction velocity is exactly half of its maximal value. K_m serves as an important measure of the affinity between an enzyme and its substrate; a lower value typically indicates tighter binding. This parameter is independent of enzyme concentration and is a characteristic property of a specific enzyme-substrate pair.

86. (D) High affinity of the enzyme for its substrate
A low Michaelis constant indicates that an enzyme reaches half of its maximal velocity at a very low substrate concentration, reflecting a high affinity for that substrate. This means the enzyme can effectively capture and process the substrate even when its availability is limited. Such enzymes are typically optimized to function in environments where substrate concentrations are consistently kept at low levels.

87. (B) When $[S] = K_m$
According to the Michaelis-Menten equation, the reaction velocity reaches exactly one-half of the maximal velocity when the substrate concentration is numerically equal to the Michaelis constant. This relationship provides a straightforward way to experimentally determine the affinity of an enzyme for its substrate. At this point, half of the enzyme's active sites are occupied by substrate molecules, forming the complex.

88. (C) The reaction follows zero-order kinetics with respect to substrate
When the substrate concentration significantly exceeds the Michaelis constant, the enzyme's active sites become fully saturated. In this state, the reaction velocity approaches $V_{\{}\max_{\}}$ and becomes independent of further increases in substrate concentration. This condition represents zero-order kinetics with respect to the substrate, where the rate is limited only by the total amount of enzyme and its inherent turnover.

89. (D) $V_{\{}\max_{\}}$
In Michaelis-Menten kinetics, the maximal velocity is the only parameter that depends directly on the total concentration of the enzyme present in the reaction. Since $V_{\{}\max_{\}}$ is the product of the turnover number and the total enzyme concentration, doubling the amount of enzyme will double the observed maximal rate. In contrast, K_m and the specificity constant are intrinsic enzyme properties.

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108. (B) Uncompetitive
A Lineweaver-Burk plot for uncompetitive inhibition displays a characteristic pattern of parallel lines. Because both $V_{\{}max_{\}}$ and K_m decrease by the same factor in the presence of the inhibitor, the ratio of K_m to $V_{\{}max_{\}}$, which determines the slope, remains constant. As the inhibitor concentration increases, the lines shift upward and to the left, reflecting the simultaneous changes in both parameters.

109. (A) Strong covalent bonds with active site residues
Irreversible inhibitors, often called inactivators, typically function by forming strong covalent bonds with essential amino acid residues within the enzyme's active site. These stable bonds permanently alter the enzyme's structure and destroy its catalytic activity. Because the inhibitor remains attached, the enzyme cannot be restored through simple dilution or dialysis, and the cell must synthesize new protein to recover activity.

110. (A) I, II and III
Mechanism-based inactivators, or suicide inhibitors, are initially unreactive but become lethal to the enzyme during the catalytic process. Affinity labels are another class that structurally mimic the substrate to target the active site for covalent modification. In contrast, irreversible inhibitors form stable bonds that cannot be reversed by dialysis, distinguishing them from the reversible binding typical of competitive or non-competitive inhibitors.

111. (D) Serine
Diisopropyl fluorophosphate is a classic irreversible inhibitor that specifically targets serine proteases and acetylcholinesterase. It reacts with the highly nucleophilic hydroxyl group of the active site serine residue, forming a stable covalent bond. This modification permanently blocks the catalytic machinery, leading to complete enzyme inactivation. Due to its effect on essential nerve enzymes, DIPF is categorized as a very potent toxin.

112. (C) Bind more tightly to the active site than the substrate does
Transition-state analogs are designed to structurally resemble the high-energy intermediate of an enzymatic reaction. Because enzymes are evolved to stabilize the transition state through maximal noncovalent interactions, these analogs bind much more tightly than the ground-state substrate. This extremely high affinity makes them potent inhibitors that effectively occupy the active site and prevent the enzyme from processing its normal biological substrates.

113. (B) Mechanism-based (suicide) inactivator
Penicillin functions as a suicide inhibitor by targeting the transpeptidase enzyme responsible for bacterial cell wall synthesis. The enzyme treats the penicillin molecule as a normal substrate and attempts to catalyze a reaction, which instead results in the formation of a permanent covalent bond between the drug and the active site. This irreversible inactivation prevents the bacterium from building a stable cell wall.

114. (D) Hijack the normal catalytic mechanism to generate a reactive intermediate
Suicide inhibitors are distinguished from generic affinity labels by their requirement for catalytic activation. While affinity labels are inherently reactive and bind directly to the active site, suicide inhibitors are chemically inert until the target enzyme attempts to process them. The enzyme's own catalytic machinery converts the inhibitor into a highly reactive species that covalently modifies and destroys the active site permanently.

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115. (A) Sigmoidal
Allosteric enzymes typically display sigmoidal velocity curves when plotting the reaction rate against substrate concentration, rather than the hyperbolic curves seen in Michaelis-Menten kinetics. This S-shaped curve reflects cooperative binding, where the interaction of substrate with one active site influences the affinity of other sites. This mechanism allows allosteric enzymes to be highly sensitive to small changes in substrate levels.

116. (C) A regulatory molecule that is also the enzyme's normal substrate
A homotropic effector is a regulatory molecule that serves both as the substrate for the enzyme and as a modulator of its activity. The binding of a homotropic effector to one subunit typically induces a conformational change that increases the affinity of the remaining subunits for the same substrate, a phenomenon known as positive

99. (A) $\frac{k_{cat}}{K_m}$
When the substrate concentration is significantly lower than the Michaelis constant, the reaction rate is directly proportional to the ratio of $k_{\{cat\}}$ to K_m. In this regime, the specificity constant acts as an apparent second-order rate constant, governing the speed at which free enzyme and free substrate react. This value determines the metabolic flux under typical physiological conditions where substrates are scarce.

100. (C) I and III
Catalytic efficiency is properly assessed by the turnover number, which is the maximal velocity per total enzyme concentration, and the specificity constant, which describes performance at low substrate levels. Contrary to some assumptions, a high K_m actually indicates lower affinity and does not imply high efficiency. Combining these parameters allows biochemists to quantify how well an enzyme functions under cellular conditions.

101. (A) The active site of the free enzyme
Reversible competitive inhibitors exert their inhibitory effect by binding specifically to the active site of the free enzyme, thereby competing directly with the substrate. Since the inhibitor and substrate cannot both occupy the active site simultaneously, the presence of the inhibitor reduces the number of enzyme molecules available to bind the substrate. This type of inhibition is common among substrate analogs.

102. (D) $V_{\{}\max_{\}}$ remains unchanged, apparent K_m increases
In competitive inhibition, the maximal velocity remains unchanged because the inhibitor can be displaced by sufficiently high substrate concentrations. However, the apparent Michaelis constant increases because more substrate is required to achieve half-maximal velocity in the presence of the competitor. This reflects a decrease in the overall affinity of the enzyme for its substrate, although the enzyme's inherent catalytic capacity is preserved.

103. (B) Intersect at the y-axis
A Lineweaver-Burk plot of competitive inhibition shows a series of lines that intersect at a single point on the y-axis. This common intercept confirms that the maximal velocity is not affected by the inhibitor. As the inhibitor concentration increases, the slope of the lines increases and the x-intercept moves closer to zero, reflecting the characteristic increase in the apparent Michaelis constant within the system.

104. (C) Both the free enzyme and the enzyme-substrate complex with equal affinity
Non-competitive inhibition occurs when an inhibitor binds to a site other than the active site, known as an allosteric site. A pure non-competitive inhibitor binds with equal affinity to both the free enzyme and the enzyme-substrate complex. Because the inhibitor does not interfere with substrate binding, the enzyme can still form the ESI complex, but this complex remains catalytically inactive.

105. (D) It decreases $V_{\{}\max_{\}}$ but leaves K_m unchanged
Pure non-competitive inhibition is characterized by a decrease in the maximal velocity while the Michaelis constant remains unchanged. The inhibitor reduces the total amount of active enzyme capable of converting substrate to product, effectively lowering the $V_{\{}\max_{\}}$. Since the inhibitor binds to the free enzyme and the ES complex with identical affinity, it does not alter the substrate binding equilibrium throughout the process.

106. (A) The enzyme-substrate (ES) complex
Uncompetitive inhibitors are unique because they do not bind to the free enzyme; instead, they bind exclusively to the enzyme-substrate complex. The binding of the substrate is required to induce a conformational change that creates the inhibitor's binding site. This type of inhibition is often observed in multi-substrate reactions and cannot be overcome by simply increasing the concentration of the substrate during catalysis.

107. (D) It decreases both $V_{\{}\max_{\}}$ and apparent K_m proportionally
Uncompetitive inhibition results in a proportional decrease in both the maximal velocity and the apparent Michaelis constant. The decrease in $V_{\{}\max_{\}}$ occurs because the inhibitor-bound ES complex cannot proceed to form product. Simultaneously, the apparent K_m decreases because the removal of the ES complex by the inhibitor shifts the binding equilibrium toward more ES formation, appearing as an increase in the binding affinity.

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permanent proteolytic cleavage of a peptide bond to reveal the active site. Once a zymogen is activated, the resulting active enzyme cannot be reverted to its inactive precursor and must eventually be degraded by cells.

126. (C) Specific proteolytic cleavage
Chymotrypsinogen is the inactive zymogen precursor of the digestive enzyme chymotrypsin. It is converted to its fully active form through a series of specific proteolytic cleavages initiated by trypsin. These cuts allow the protein to rearrange its structure, forming the catalytic triad and the oxyanion hole necessary for catalysis. This activation occurs only in the small intestine to protect pancreatic tissues.

127. (D) To prevent premature degradation of the tissues that synthesize them
Many digestive proteases are synthesized as inactive zymogens to prevent the premature degradation of the cells and tissues where they are produced. By keeping these powerful enzymes inactive until they reach the digestive tract, the body avoids self-digestion and potential organ damage, such as pancreatitis. This protective mechanism ensures that the enzymes only become active in the appropriate physiological environment.

128. (C) Glutamine synthetase
In Escherichia coli, the activity of glutamine synthetase is regulated by the reversible covalent attachment of an adenosine monophosphate group, a process called adenylylation. When the enzyme is adenylylated, its activity is inhibited, whereas the removal of the AMP group restores its function. This complex regulatory system allows the bacterium to precisely control nitrogen assimilation in response to changing levels of metabolites.

129. (B) Different structural forms of an enzyme within a single organism that catalyze the same reaction
Isoenzymes, or isozymes, are different structural forms of an enzyme within a single organism that catalyze the same chemical reaction. Although they perform the same function, they often differ in their amino acid sequences, kinetic properties, and regulatory mechanisms. These variations allow different tissues to tailor their metabolic activity to meet specific physiological requirements, such as oxygen availability or substrate concentration.

130. (A) Both A and R are true and R is the correct explanation of A.
Isoenzymes display distinct kinetic and regulatory characteristics because they are encoded by different genes or composed of varying subunit combinations. These structural differences, though subtle, result in variations in substrate affinity and sensitivity to allosteric modulators. This diversity allows an organism to fine-tune the same chemical reaction across different tissues, ensuring that metabolism is perfectly adapted to the local environment.

131. (A) M (Muscle) and H (Heart)
Lactate dehydrogenase is a tetrameric enzyme composed of two distinct subunit types: the M (Muscle) type and the H (Heart) type. These subunits are encoded by different genes and can combine in five different ways to form the LDH isoenzymes. The specific combination of M and H subunits determines the kinetic properties and tissue distribution of each isoenzyme, reflecting its role.

132. (C) Five
There are five distinct tetrameric isoenzymes of lactate dehydrogenase found in human tissues, ranging from the pure heart form to the pure muscle form. These include LDH-1 (H4), LDH-2 (H3M1), LDH-3 (H2M2), LDH-4 (H1M3), and LDH-5 (M4). Each isoenzyme has a unique electrophoretic mobility and localized expression pattern, which is used by clinicians to diagnose specific organ damage through blood tests.

133. (A) Heart muscle
The LDH-1 isoenzyme, which consists of four H subunits, is found in the highest concentration in the heart muscle and red blood cells. It is specifically adapted for the aerobic environment of the heart, where it efficiently catalyzes the oxidation of lactate back into pyruvate. Because of its tissue specificity, elevated levels of LDH-1 in the serum are a traditional marker for myocardial.

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134. (D) Anaerobic reduction of pyruvate to lactate
The M-rich isoenzymes of lactate dehydrogenase, such as LDH-5, are predominantly found in skeletal muscle and the liver. These forms are physiologically optimized for anaerobic

cooperativity. This process is central to sigmoidal kinetics.

117. (A) The enzyme exists in an equilibrium between distinct T (tense) and R (relaxed) states
The concerted or MWC model of allosterism proposes that an enzyme exists in an equilibrium between two distinct conformational states: the T (tense) state with low affinity and the R (relaxed) state with high affinity. In this model, all subunits of the multimeric enzyme must transition between these states simultaneously, ensuring that the entire protein maintains structural symmetry throughout the process.

118. (D) Binding of a ligand to one subunit alters the conformation of that specific subunit and influences its neighbors
The sequential or KNF model of allosterism posits that ligand binding induces a conformational change in an individual subunit, which then influences the affinity of adjacent subunits through induced fit. Unlike the concerted model, the sequential model allows for hybrid states where some subunits are in the high-affinity form while others remain in the low-affinity form. This model provides flexibility.

119. (B) Binding to regulatory sites distinct from the active site
Heterotropic effectors are regulatory molecules that are structurally different from the enzyme's substrate. They control enzyme activity by binding to specific allosteric sites located away from the active site. These effectors can either stabilize the high-affinity R state to activate the enzyme or stabilize the low-affinity T state to inhibit it, providing the cell with a sophisticated mechanism for metabolic control.

120. (A) II, III, IV and V
Allosteric regulation is characterized by sigmoidal kinetics and cooperativity between subunits. The T state typically possesses a lower substrate affinity than the R state, and homotropic effectors generally serve as positive modulators. While the sequential model allows for individual subunits to change independently, the concerted model strictly requires simultaneous transitions, maintaining symmetry. These principles are vital for fine-tuning metabolic pathways.

121. (D) Phosphorylation
Phosphorylation is the most prevalent form of reversible covalent modification used to regulate enzyme activity in eukaryotic organisms. By adding a bulky, negatively charged phosphate group to specific amino acid residues, the enzyme's conformation and catalytic properties can be rapidly altered. This process is mediated by protein kinases and can be reversed by phosphatases, allowing the cell to respond quickly to environmental stimuli.

122. (A) Serine, Threonine, and Tyrosine
Protein kinases regulate enzymes by catalyzing the transfer of a phosphate group from ATP to the hydroxyl group of specific amino acid side chains. The three primary targets for this modification are serine, threonine, and tyrosine residues. The addition of the phosphate group introduces significant electrostatic changes that can either activate or inhibit the target enzyme, depending on the specific cellular regulatory context.

123. (D) Phosphatases
The regulatory action of protein kinases is reversed by a class of enzymes known as phosphatases. These enzymes catalyze the hydrolytic removal of phosphate groups from phosphorylated amino acid residues, restoring the target protein to his original state. The dynamic balance between the opposing activities of kinases and phosphatases allows for the precise and reversible control of many essential biological signaling pathways.

124. (B) Reversible covalent phosphorylation
Glycogen phosphorylase is a sophisticated enzyme that undergoes complex regulation involving both allosteric modulators and reversible covalent phosphorylation. In its phosphorylated form, the enzyme is highly active and less sensitive to allosteric inhibitors, ensuring rapid glycogen breakdown when energy is needed. This dual regulatory mechanism allows the cell to integrate various hormonal and metabolic signals to effectively manage its internal glucose stores.

125. (A) Physiologically irreversible
A primary distinction between zymogen activation and phosphorylation-based regulation is that the former is physiologically irreversible. While phosphorylation can be easily undone by phosphatases, zymogen activation involves the

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groups are the epsilon-amino groups of lysine residues or the sulfhydryl groups of cysteine. This method provides a very secure attachment that prevents enzyme leakage, although care must be taken to avoid modifying the catalytic active site.

144. (C) Mass transfer limitations leading to an increased apparent K_m
A common kinetic consequence of enzyme immobilization is the emergence of mass transfer limitations, where the rate of substrate diffusion to the active site becomes slower than the catalytic rate itself. This often leads to a significant increase in the apparent Michaelis constant, as higher bulk substrate concentrations are needed to saturate the immobilized enzyme. Such diffusion effects must be managed.

145. (B) Weak interactions such as van der Waals forces and ionic bonds
Immobilization via physical adsorption relies on relatively weak, reversible interactions between the enzyme and a solid support surface, such as silica or charcoal. These forces include van der Waals interactions, hydrogen bonds, and ionic attractions. While this method is simple and maintains high catalytic activity by avoiding chemical modification, it carries a risk of enzyme leakage if the environmental conditions shift.

146. (D) It does not require a solid support matrix, reducing bulk
Cross-linking is an immobilization technique that involves chemically joining enzyme molecules together using bifunctional reagents like glutaraldehyde. One significant advantage of this method is that it does not require a solid support matrix, which reduces the overall volume of the biocatalyst and avoids dilution of activity. The resulting enzyme aggregates are highly stable and can be easily recovered from the mixture.

147. (A) Diffusion of substrate into the immobilization matrix
In bioreactors using immobilized enzymes, the overall reaction rate is often governed by the diffusion of substrate molecules from the bulk liquid into the matrix where the enzyme is trapped. This transport phenomenon creates concentration gradients that can limit the efficiency of the catalyst. Engineers must design systems that optimize the balance between the catalytic rate and the rate of mass transfer.

148. (C) High-fructose corn syrup and textiles
Microbial amylases are used extensively in the industrial processing of starch, playing a central role in the production of high-fructose corn syrup and the sizing of textiles. These enzymes break down complex starches into smaller maltodextrins and glucose units, which are then further processed into sweeteners. Their stability and efficiency at high temperatures make them ideal for the liquefaction step.

149. (A) Protease (e.g., mucorpepsin)
In the dairy industry, microbial proteases such as mucorpepsin are widely used as effective rennet substitutes for the coagulation of milk during cheese production. These enzymes mimic the action of traditional calf chymosin by specifically cleaving kappa-casein, which destabilizes milk micelles and leads to curd formation. The use of microbial sources provides a reliable, ethical, and cost-effective alternative to animal enzymes.

150. (A) Liquefaction by alpha-amylase → Saccharification by glucoamylase → Isomerization (if making syrup)
The industrial conversion of starch to syrup follows a logical three-step enzymatic sequence: liquefaction by alpha-amylase to reduce viscosity, saccharification by glucoamylase to release individual glucose molecules, and finally isomerization by glucose isomerase to produce fructose. This coordinated process allows for the efficient large-scale manufacture of sweeteners with specific sugar profiles tailored for use in the food and beverage industry.

151. (B) Biological laundry detergents
Alkaline proteases are essential ingredients in modern biological laundry detergents because they can effectively degrade protein-based stains, such as blood and grass, at high pH. These enzymes are specially selected or engineered to remain stable and active in the presence of surfactants and bleaching agents. Their inclusion allows for efficient cleaning at lower temperatures, saving energy and reducing environmental impact.

152. (D) Clarifying fruit juices by degrading plant cell wall components
Pectinases are highly valued in the beverage industry for their ability to break down pectin, a complex polysaccharide that gives fruit juices a cloudy appearance. By degrading these plant

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hydrolysis of urea but shows no activity toward other nitrogen-containing molecules.

225. (B) Affinity (K_m) for glucose and tissue distribution
Glucokinase and hexokinase are classic examples of isoenzymes that differ predominantly in their affinity for glucose and their tissue distribution. Hexokinase has a very low K_m, allowing it to function at low glucose levels in most tissues. In contrast, glucokinase, found in the liver and pancreas, has a much higher K_m, enabling it to respond specifically to high blood sugar.

226. (D) Covalently attached coenzyme
A prosthetic group is functionally and structurally analogous to a covalently attached coenzyme that remains permanently bound to the enzyme throughout the catalytic cycle. Unlike co-substrates that dissociate after the reaction, prosthetic groups are fixed parts of the holoenzyme's active site. They often play critical roles in electron transport or chemical group stabilization and must be regenerated before next turnover.

227. (A) 3
A phosphatase is an enzyme that catalyzes the removal of a phosphate group from a substrate through the addition of a water molecule, a process known as hydrolysis. According to the International Union of Biochemistry and Molecular Biology, all enzymes that perform hydrolytic cleavage are categorized under EC Class 3. Therefore, the first digit for any generic phosphatase is three.

228. (C) Oxidoreductases
Dehydrogenases are a major group of enzymes classified under the oxidoreductase class, EC Class 1. They catalyze oxidation-reduction reactions by facilitating the transfer of hydrogen atoms or electrons from a substrate to an electron carrier, such as NAD+ or FAD. These enzymes are essential for cellular respiration and energy production, managing the high-energy electrons extracted from the biological fuels.

229. (A) Pyridoxal phosphate (PLP)
Transaminases are vital enzymes that shuffle an amino group from an amino acid to a keto acid, a process that requires the coenzyme pyridoxal phosphate. PLP is derived from vitamin B_6 and acts by forming a temporary Schiff base with the substrate. This intermediate allows the enzyme to stabilize various transition states, facilitating the essential interconversion of amino acids.

230. (A) P-2, Q-4, R-1, S-3
Enzymatic catalysis utilizes diverse strategies: covalent catalysis forms transient electron-sharing bonds, while general acid-base catalysis involves direct proton transfer from amino acid side chains. Metal ion catalysis often relies on electron withdrawal by a fixed cationic center, and proximity effects work by bringing reactive groups close together. Together, these mechanisms allow enzymes to achieve remarkable speed and specificity in biological.

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231. (B) Initial reaction velocities where product concentration is negligible
The Michaelis-Menten kinetic model is strictly valid only when investigating initial reaction velocities where the concentration of the product is negligible. This prevents the back-reaction from product to substrate from complicating the measurements. By focusing on the very beginning of the reaction, researchers can more accurately determine the fundamental kinetic constants, such as K_m and $V_{\{}\max_{\}}$, for enzyme-substrate pairs.

232. (C) $\frac{K_m}{V_{\max}}$
In a Lineweaver-Burk double reciprocal plot, the slope of the line is mathematically defined as the ratio of the Michaelis constant to the maximal velocity. This value represents the increase in the reciprocal of the velocity for every unit increase in the reciprocal of the substrate concentration. Analyzing changes in this slope is essential for identifying different types of enzyme inhibition.

233. (D) $\frac{v}{[S]}$
The Eadie-Hofstee plot is a linear transformation of the Michaelis-Menten equation that expresses the reaction velocity against the ratio of the velocity to the substrate concentration. The resulting plot yields a straight line with a slope equal to negative K_m and a y-intercept equal to $V_{\{}\max_{\}}$. This method is often preferred for visualizing data because it does not compress high-substrate points.

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which can then be integrated into the host cell's genome. The discovery of this enzyme challenged the central dogma of molecular biology and provided a powerful new tool for researchers to manipulate genetic information.

162. (D) Withstands the high temperatures required for DNA denaturation without irreversible inactivation
Taq DNA polymerase is a fundamental component of the Polymerase Chain Reaction because of its remarkable thermostability. It remains active even after being subjected to the high temperatures required to denature double-stranded DNA, typically around ninety-five degrees Celsius. This property eliminates the need to add fresh enzyme after each thermal cycle, allowing for the automated and efficient amplification of sequences.

163. (A) They are denatured and destroyed during the $94 - 96^{\circ}C$ heating step
Mesophilic DNA polymerases, such as those from E. coli, are unsuitable for modern PCR because they are irreversibly denatured during the high-temperature denaturation phase of the reaction. To use these enzymes, researchers would have to manually add fresh protein after every single cycle, which is labor-intensive and prone to contamination. The introduction of thermostable enzymes solved this problem for automation.

164. (C) It lacks $3â€™ \rightarrow 5â€™$ exonuclease (proofreading) activity
A significant kinetic limitation of standard Taq DNA polymerase is its lack of three-prime to five-prime exonuclease activity, which serves as a proofreading mechanism. As a result, the enzyme is unable to correct misincorporated nucleotides during DNA synthesis, leading to a relatively high error rate in the final PCR product. This makes Taq less ideal for applications requiring absolute sequence fidelity.

165. (A) Pfu DNA polymerase
To achieve high fidelity in PCR, researchers often utilize Pfu DNA polymerase, which is isolated from the hyperthermophilic archaeon Pyrococcus furiosus. Unlike Taq, Pfu possesses an intrinsic three-prime to five-prime exonuclease proofreading activity that allows it to remove and correct mismatched bases. This significantly reduces the mutation rate, making it the preferred choice for cloning and high-precision applications.

166. (D) Add a non-templated single adenine (A) residue to the 3' ends of the PCR product
A unique and useful property of Taq DNA polymerase is its terminal transferase activity, which tends to add a single non-templated adenine residue to the three-prime ends of PCR products. This feature is exploited in TA cloning, where the A-overhangs of the PCR fragment base-pair with T-overhangs on a specialized linearized vector. This simplified method allows for efficient cloning.

167. (C) $72^{\circ}C$
In a typical PCR cycle, the elongation or extension phase is conducted at seventy-two degrees Celsius. This temperature is the catalytic optimum for Taq DNA polymerase, allowing for the rapid and efficient synthesis of new DNA strands complementary to the template. During this step, the enzyme incorporates deoxynucleotides at a high rate, typically extending the DNA at about one thousand bases.

168. (A) Automated thermal cycling without the need to add fresh enzyme every cycle
The discovery and application of thermostable enzymes like Taq polymerase fundamentally transformed molecular biology by enabling automated thermal cycling. Before their use, PCR was extremely tedious, requiring the manual addition of fresh polymerase after each high-temperature denaturation step. With thermostable enzymes, the entire amplification process can be completed in a single closed tube within a thermocycler, increasing speed.

169. (D) Have a slower extension rate due to active proofreading mechanisms
High-fidelity polymerases like Pfu generally exhibit a slower extension rate compared to Taq polymerase because of their active proofreading mechanism. The enzyme must take the time to check each incorporated base and remove any errors via its exonuclease activity before proceeding with synthesis. While this results in a longer reaction time, it ensures much higher accuracy in amplified DNA.

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170. (A) Both A and R are true and R is the correct explanation of A.
Thermostable enzymes maintain their functional tertiary structure at extreme temperatures because of specific structural adaptations. These include a higher density of internal salt bridges, extensive ionic networks, and a more hydrophobic core compared to their mesophilic counterparts. These features provide the necessary structural rigidity to resist thermal denaturation, ensuring the enzyme remains active throughout demanding cycles of a PCR reaction.

171. (B) Proteins
The discovery of ribozymes demonstrated that catalytic power is not restricted to proteins, as previously believed. These RNA molecules possess complex tertiary structures that create active sites capable of facilitating chemical reactions with high specificity and speed. By showing that nucleic acids can also function as biocatalysts, ribozymes provided critical evidence for the RNA world hypothesis and expanded biological understanding.

172. (B) Antibody enzyme
The term "abzyme" is a portmanteau derived from the words "antibody" and "enzyme," reflecting its dual nature as an immunoglobulin with catalytic activity. These molecules are generated using the immune system to recognize and bind the transition state of a specific chemical reaction. By combining the high binding specificity of antibodies with catalytic power, abzymes serve as tools for specialized transformations.

173. (A) The abzyme specifically binds and stabilizes the transition state of a target reaction
What distinguishes an abzyme's binding mechanism from a traditional antibody is its specific affinity for the transition state of a target reaction. While standard antibodies bind to ground-state antigens, abzymes are elicited against stable transition-state analogs. By binding and stabilizing the high-energy intermediate, the abzyme lowers the activation energy, effectively acting as a catalyst to accelerate the biochemical process.

174. (C) A slow reaction rate
In enzyme kinetics, a high activation energy represents a significant energy barrier that reacting molecules must overcome to reach the transition state. According to the Arrhenius equation, the reaction rate constant is inversely and exponentially related to the activation energy. Therefore, a high E_a results in a much slower reaction rate, as fewer molecules possess sufficient energy to react.

175. (D) At chemical equilibrium
A change in Gibbs free energy equal to zero signifies that a chemical system has reached a state of dynamic equilibrium. At this point, the free energy of the reactants and products is balanced, and there is no thermodynamic drive for the reaction to proceed in either direction. While individual molecules continue to react, the net concentrations of all species remain constant.

176. (C) Transition state
For a chemical reaction to occur, a reacting molecule must achieve the transition state, which is the high-energy, unstable configuration where bonds are in the process of breaking and forming. This state represents the peak of the energy barrier that must be crossed for the reactants to transform into products. Catalysts work by lowering the energy required to reach this state.

177. (B) Reaction rate constant and activation energy
The Arrhenius equation provides a mathematical description of how the reaction rate constant depends on the temperature and the activation energy. It illustrates that the rate of a chemical process increases exponentially as the activation energy is lowered or as the temperature is raised. This fundamental relationship is essential for understanding how enzymes effectively accelerate biochemical reactions by reducing barriers.

178. (D) Active site
The specificity of an enzyme is primarily determined by the unique three-dimensional arrangement of amino acid residues within its active site. This specialized pocket provides a microenvironment that is structurally and chemically complementary to a specific substrate. The precise positioning of various functional groups allows for the formation of multiple weak interactions, ensuring that only the correct molecule can bind.

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179. (A) Temporarily carrying a chemical group between different enzymes
A co-substrate acts by temporarily binding to an enzyme to participate in a catalytic cycle, often by carrying a specific chemical group or electrons. During the reaction, the co-substrate is chemically modified and then dissociates from the enzyme's active site. It is subsequently regenerated by another enzyme elsewhere in the cell, allowing it to move between different metabolic pathways.

180. (A) P-2, Q-4, R-1, S-3
Different coenzymes specialize in transferring specific chemical entities: NAD+ carries electrons and hydride ions, while ATP is the primary donor of phosphate groups. Coenzyme A is essential for transporting acyl groups, and tetrahydrofolate is involved in the movement of various one-carbon units. These cofactors are indispensable for the coordination of complex metabolic networks, ensuring that groups are delivered precisely.

181. (A) Isomerases
Under the systematic IUBMB nomenclature, EC Class 5 is designated for isomerases. These enzymes catalyze structural or geometric changes within a single molecule, facilitating the interconversion of different isomers. This class includes various subclasses such as racemases, epimerases, and mutases. Isomerases are critical for preparing molecules for specific metabolic pathways by ensuring they possess the correct three-dimensional configuration for steps.

182. (D) Hydrolase
A peptidase is an enzyme that catalyzes the breakdown of proteins into smaller peptides or individual amino acids through the hydrolytic cleavage of peptide bonds. Because this process involves the addition of a water molecule to break the covalent bond, peptidases are classified as hydrolases. These enzymes are essential for digestion and cellular protein turnover, simplifying complex proteins into basic building blocks.

183. (C) Lyases
Decarboxylases are enzymes that catalyze the removal of a carboxyl group from a substrate, releasing it as carbon dioxide. Because they function by cleaving a C-C bond without the addition of water or the transfer of electrons, they are classified as lyases. These enzymes often require cofactors like pyridoxal phosphate or thiamine pyrophosphate and play vital roles in metabolism.

184. (D) Conformational flexibility
The induced fit model of enzyme action is fundamentally based on the concept of conformational flexibility. It suggests that both the enzyme's active site and the substrate can undergo structural changes upon binding to achieve a perfect fit. This dynamic adjustment allows the enzyme to stabilize the transition state more effectively, enhancing its catalytic power compared to a rigid template.

185. (A) Highly specific proteases recognizing small rigid substrates
Although most enzymes exhibit some degree of flexibility, highly specific proteases that recognize small, rigid substrates are often cited as examples that closely approximate the lock-and-key model. In these cases, the active site is a relatively rigid structure that requires a precise structural match from the substrate for binding to occur. This rigidity ensures that only the target is processed.

186. (A) Decreasing the entropy of the reacting molecules
In proximity and orientation catalysis, the enzyme accelerates the reaction by decreasing the translational and rotational entropy of the reacting molecules. By binding the substrates in a fixed, optimal orientation within the active site, the enzyme makes the collision between reactive groups much more frequent. This localized reduction in randomness significantly lowers the energy barrier required to reach the transition state.

187. (D) Donate a proton
In general acid catalysis, an amino acid residue within the enzyme's active site acts as a Bronsted-Lowry acid by donating a proton to the substrate. This proton transfer helps to stabilize a developing negative charge or facilitates the departure of a leaving group in the transition state. The strategic donation of protons is a powerful way for enzymes to accelerate transformations.

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which is more specific, strongly confirms the presence of pancreatic tissue damage.

207. (D) Alginate
Alginate is a naturally derived polysaccharide obtained from brown seaweed that is commonly used for the gentle entrapment of fragile cells and enzymes. When mixed with calcium ions, it forms a stable, porous gel matrix that keeps the biocatalyst sequestered while allowing substrates and products to diffuse freely. Its biocompatibility and mild gelation conditions make it an ideal biotechnology choice.

208. (C) Glutaraldehyde
Glutaraldehyde is a widely used bifunctional cross-linking reagent that facilitates the covalent coupling of enzymes to a support matrix or to each other. It functions by reacting with the primary amino groups of lysine residues on the protein surface, creating stable inter- and intra-molecular bridges. This immobilization method is highly effective for preventing enzyme leakage and enhancing the operational stability of catalysts.

209. (B) The ratio of the actual reaction rate to the rate without diffusion limitations
The effectiveness factor in bioreactor kinetics is a dimensionless parameter that quantifies the impact of mass transfer limitations on the performance of immobilized enzymes. It is defined as the ratio of the actual observed reaction rate to the rate that would occur if the entire enzyme population were exposed to the bulk substrate concentration without any diffusion resistance within the matrix.

210. (B) I, II, IV and V
Industrial enzymes play diverse roles across multiple sectors: amylases and pectinases are essential for food and beverage processing, while lipases and cellulases facilitate the production of biodiesel and paper. Contrary to being avoided, alkaline proteases are widely used in detergents due to their stability. Together, these applications demonstrate the immense versatility and economic importance of biocatalysts in sustainable industrial manufacturing.

211. (A) Glucose
Cellulases are a group of enzymes that work synergistically to break down cellulose, a complex plant polysaccharide, into individual glucose molecules. This process involves the sequential action of endoglucanases, exoglucanases, and beta-glucosidases to cleave the beta-1,4-glycosidic bonds. In industrial bioprocessing, cellulases are essential for converting biomass into fermentable sugars, which can then be used to produce bioethanol and biofuels.

212. (C) Either sticky or blunt ends depending on the specific enzyme
Type II restriction endonucleases are versatile tools that can cleave DNA to produce either sticky ends with overhanging single-stranded sequences or blunt ends with perfectly flush double-stranded terminations. The type of end generated depends on the specific enzyme used and its unique recognition and cleavage pattern. Both types of ends are valuable in recombinant technology, though sticky ends facilitate ligation.

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213. (A) Protect against invading viral (bacteriophage) DNA
The natural biological function of restriction endonucleases in bacteria is to serve as a primitive immune system that protects against invading viral DNA from bacteriophages. These enzymes recognize and cleave foreign DNA at specific sequences, effectively neutralizing the threat. By degrading the viral genome before it can replicate, the bacteria ensure their survival, a mechanism that scientists successfully repurposed.

214. (D) By methylating specific bases within the recognition sequences
Bacterial cells prevent their own restriction enzymes from cleaving their genomic DNA by utilizing specific methyltransferase enzymes. These enzymes add a methyl group to specific bases within the recognition sequences, which physically blocks the restriction endonuclease from binding or cutting the DNA. This sophisticated restriction-modification system allows the bacterium to distinguish between its own protected genetic material and the unmethylated DNA.

215. (B) A short complementary primer
Like all DNA polymerases, reverse transcriptase requires a short complementary primer to initiate the synthesis of a new DNA strand from an RNA template. The primer provides the necessary three-prime hydroxyl group for the addition of the first deoxynucleotide. In the laboratory,

permanently disrupts the enzyme's structure and catalytic function, leading to serious systemic health issues and potentially fatal consequences.

198. (D) Irreversible inhibitors of acetylcholinesterase
Nerve gases like sarin are extremely lethal because they act as irreversible inhibitors of the enzyme acetylcholinesterase. By forming a stable covalent bond with a critical serine residue in the active site, these agents prevent the breakdown of the neurotransmitter acetylcholine. This leads to the continuous stimulation of muscles and glands, resulting in respiratory failure and death within minutes.

199. (B) $n_H > 1$
An allosteric enzyme exhibiting positive cooperativity will have a Hill coefficient greater than one. This value indicates that the binding of one substrate molecule to a subunit increases the affinity of the remaining subunits for the substrate. The higher the Hill coefficient, the more sigmoidal the velocity curve and the more sensitive the enzyme is to small substrate concentration changes.

200. (A) I and IV
Phosphorylation is a key regulatory mechanism that typically targets the hydroxyl groups of serine, threonine, or tyrosine residues. This covalent modification can either activate or inhibit the target enzyme, depending on the specific biological context. While zymogen activation is often triggered by proteolysis, allosteric modulators usually bind to regulatory sites distinct from the active site, providing sophisticated cellular control.

201. (D) Calmodulin
Calmodulin is a highly conserved calcium-binding protein that acts as a primary sensor for intracellular calcium levels. Upon binding calcium, calmodulin undergoes a significant conformational change that allows it to interact with and regulate various target proteins, including kinases and phosphatases. This mechanism is central to many signaling pathways, linking calcium fluctuations to changes in enzyme activity and other vital processes.

202. (A) Sequential zymogen activation (a proteolytic cascade)
The intrinsic pathway of blood coagulation is a classic example of a proteolytic cascade, where a series of enzymes are sequentially activated through the cleavage of their zymogen precursors. This multi-step process allows for a rapid and highly amplified response to vascular injury, ensuring the timely formation of a stable fibrin clot. Each activated factor serves as the next catalyst.

203. (D) Gene duplication events leading to divergent paralogs
The genetic origin of isoenzymes frequently involves gene duplication events, where an ancestral gene is copied, allowing the resulting paralogs to diverge and evolve distinct properties. Over time, these duplicated genes may develop different tissue-specific expression patterns and unique kinetic characteristics. This evolutionary strategy enables an organism to maintain the same basic catalytic function while specializing its performance for diverse environments.

204. (B) They exhibit distinct tissue-specific expression patterns
Specific isoenzyme profiles are invaluable for clinical diagnosis because they exhibit distinct, tissue-specific expression patterns. For example, certain forms of lactate dehydrogenase or creatine kinase are found only in the heart, while others predominate in the liver or skeletal muscle. By identifying which isoenzyme is elevated in a patient's serum, clinicians can accurately determine the specific organ that has suffered injury.

205. (A) Acute myocardial infarction
Historically, an "LDH flip," where serum levels of LDH-1 exceed those of LDH-2, was a key diagnostic indicator for acute myocardial infarction. Since the heart muscle is rich in LDH-1, its release into the blood following a heart attack reverses the normal ratio found in healthy individuals. While modern troponin tests have largely replaced it, the LDH flip remains important.

206. (C) Acute pancreatitis
Amylase and lipase levels are routinely measured together to provide a reliable diagnosis of acute pancreatitis. Both enzymes are produced by the pancreas and released into the small intestine; however, when the organ becomes inflamed, they leak into the systemic circulation. A significant elevation in both enzymes, particularly lipase

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188. (A) The metal ion is tightly retained during isolation and purification
A true metalloenzyme is distinguished from a metal-activated enzyme by the strength of its association with the metal ion. In metalloenzymes, the metal is a permanent structural component that is tightly retained even during rigorous purification processes. In contrast, metal-activated enzymes only loosely bind their metal cofactors, which can easily dissociate and are often exchanged with the surrounding solvent.

189. (A) Collagen
Vitamin C, or ascorbic acid, acts as a crucial coenzyme for the enzymes prolyl and lysyl hydroxylase, which are responsible for the post-translational modification of collagen. By facilitating the hydroxylation of specific amino acid residues, vitamin C ensures the formation of stable cross-links that give collagen its high tensile strength. A deficiency in this vitamin leads to scurvy and weakness.

190. (A) I and II
Pantothenic acid is an essential building block of Coenzyme A, and folic acid is indispensable for managing one-carbon transfer reactions in the cell. However, biotin is not involved in transaminations; instead, it serves as a coenzyme for carboxylase enzymes. Understanding these specific vitamin-coenzyme relationships is vital for mastering the biochemical foundations of nutrition and the regulation of metabolic pathways.

191. (D) Rectangular hyperbola
The standard Michaelis-Menten kinetic curve, which plots the initial reaction velocity against the substrate concentration, follows the shape of a rectangular hyperbola. At low substrate levels, the rate increases almost linearly, reflecting first-order kinetics. As the substrate concentration rises, the enzyme's active sites become increasingly occupied, and the curve flattens out as it asymptotically approaches the maximal reaction velocity.

192. (C) $k_{\{cat\}}$
The turnover number, denoted as $k_{\{cat\}}$, is the kinetic parameter that indicates the maximum number of substrate molecules a single active site can convert into product every second. This value is measured under saturating conditions where the enzyme is working at its maximum capacity. $k_{\{cat\}}$ provides a direct measure of the catalytic speed of an enzyme, independent of its affinity.

193. (B) $\frac{K_m}{V_{\max}}$
In a Hanes-Woolf plot, where the ratio of substrate concentration to velocity is plotted against the substrate concentration, the y-intercept is equal to the ratio of the Michaelis constant to the maximal velocity. This linear transformation provides an alternative way to visualize kinetic data, helping to minimize the impact of experimental errors. The x-intercept of this plot gives negative K_m.

194. (D) Because it binds the substrate with high affinity and converts it rapidly
An enzyme with a high $\frac{k_{cat}}{K_m}$ ratio operates efficiently at low substrate concentrations because it possesses both high affinity for its substrate and a fast catalytic turnover rate. The low K_m ensures that the enzyme can bind the substrate even when it is scarce, while the high $k_{\{cat\}}$ ensures that once bound, the substrate is quickly transformed into product for cells.

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195. (A) The x-axis
A Lineweaver-Burk plot of pure non-competitive inhibition shows lines that intersect at a single point on the x-axis. This reflects the fact that a non-competitive inhibitor decreases the maximal velocity without affecting the Michaelis constant. Because the inhibitor binds equally well to both the free enzyme and the ES complex, it reduces the total number of active enzyme molecules.

196. (C) Binds both free enzyme and ES complex, but with unequal affinities
Mixed inhibition is characterized by an inhibitor that binds to both the free enzyme and the enzyme-substrate complex, but with different affinities for each. This results in changes to both the maximal velocity and the Michaelis constant. Unlike pure non-competitive inhibition, the lines on a Lineweaver-Burk plot for mixed inhibition intersect at a point that is off both axes.

197. (A) Irreversible binding to sulfhydryl groups
Heavy metal toxicity from elements like lead or mercury often results from the irreversible inhibition of essential enzymes. These metals typically form strong, stable covalent bonds with the sulfhydryl groups of cysteine residues located within or near the active site. This modification

synthetic primers such as oligo-dT are often used to target the poly-A tail of eukaryotic mRNA.

216. (C) It lacks 3' → 5' exonuclease proofreading activity
Reverse transcriptase is highly error-prone because it lacks the three-prime to five-prime exonuclease activity required for proofreading. This means the enzyme cannot detect or correct misincorporated nucleotides during the synthesis of DNA from the RNA template. This lack of fidelity is a significant feature of retroviral replication, contributing to high mutation rates that help viruses like HIV evade immunity.

217. (D) Separate the double-stranded DNA into single strands
The denaturation step in a standard PCR cycle is achieved by heating the reaction mixture to approximately ninety-five degrees Celsius. This high temperature provides sufficient thermal energy to break the hydrogen bonds between complementary base pairs, causing the double-stranded DNA template to separate into individual single strands. This separation is essential to provide the template needed for primer binding and synthesis.

218. (A) The length and GC-content of the specific primers
The annealing temperature used in a typical PCR protocol is primarily determined by the specific length and GC-content of the primers being used. A higher GC-content increases the melting temperature because of the three hydrogen bonds between guanine and cytosine. Choosing the correct annealing temperature is critical to ensure that primers bind specifically to their targets while minimizing non-specific DNA amplification.

219. (B) Increased core hydrophobicity and extensive salt bridge networks
Thermostability in enzymes like Taq polymerase is achieved through structural adaptations that reinforce the protein against heat-induced denaturation. These include an increased number of internal salt bridges, extensive ionic networks, and a more compact, hydrophobic core. By maximizing these stabilizing interactions, the enzyme maintains its functional three-dimensional shape even at the high temperatures required for the DNA denaturation steps.

220. (A) Both A and R are true and R is the correct explanation of A.
The specificity constant of an enzyme, which measures its catalytic efficiency, has a physical upper limit determined by the rate of diffusion. This is because no enzyme can catalyze a reaction faster than it can randomly collide with its substrate molecule in solution. When an enzyme reaches this diffusion-limited rate, it is considered catalytically perfect, representing evolutionary optimization.

221. (A) The ratio $\frac{k_{cat}}{K_m}$
The ratio of the turnover number to the Michaelis constant, known as the specificity constant, provides the best comparison of an enzyme's preference for competing alternative substrates. This value accounts for both the speed of catalysis and the strength of substrate binding. By comparing the specificity constants for different molecules, researchers can determine which substrate the enzyme will process most efficiently.

NODIA

222. (C) Esterase
An abzyme generated against a transition-state analog of an ester hydrolysis reaction will likely function as an esterase. By mimicking the electronic and structural features of the high-energy intermediate, the analog induces the production of an antibody with an active site that stabilizes the actual transition state. This stabilization lowers the activation energy for the hydrolytic cleavage of ester bonds.

223. (D) Activation energy (E_a)
The activation energy is the thermodynamic parameter represented by the height of the energy peak between the ground state of the reactants and the transition state. It defines the energy barrier that must be overcome for a chemical reaction to occur. Enzymes function by specifically lowering this peak, allowing a greater proportion of molecules to react at physiological temperatures and speeds.

224. (C) Exclusively one single specific substrate
Absolute specificity is a hallmark of certain enzymes that will only act upon one single, specific substrate molecule and no other related compounds. This extreme selectivity is often essential for maintaining the high precision of metabolic control in complex biological systems. A classic example is urease, which catalyzes the

cell wall components, pectinases clarify the juice, increase the yield during extraction, and improve the efficiency of filtration processes. This leads to a more visually appealing product and a more efficient process.

153. (D) Biodiesel
Industrial lipases are deployed in the synthesis of biodiesel, where they catalyze the transesterification of vegetable oils or animal fats with alcohols to produce fatty acid methyl esters. Unlike traditional chemical catalysts, lipases operate under milder conditions and can process feedstocks with high free fatty acid content more efficiently. This enzymatic approach offers a greener and more sustainable alternative for fuel.

154. (A) Palindromic
Restriction endonucleases typically recognize specific DNA sequences that are palindromic, meaning the sequence reads the same in the five-prime to three-prime direction on both complementary strands. This structural symmetry allows the enzyme, which often functions as a homodimer, to bind and cleave the double-stranded DNA at precise locations. These unique recognition sites are the foundation of precision gene editing.

155. (D) Type II
Type II restriction endonucleases are the most commonly used tools in molecular biology because they cleave DNA at specific, predictable sites within or very close to their recognition sequences. Unlike Type I and Type III enzymes, they do not require ATP for their catalytic activity and operate with high precision. This reliability makes them indispensable for mapping genomes and constructing recombinant plasmids.

156. (A) II, III, I, IV
The construction of a recombinant plasmid follows a logical sequence: first, both the vector and the target DNA are digested with restriction enzymes to create compatible ends. Next, DNA ligase is used to join these fragments covalently. The resulting recombinant DNA is then transformed into host cells, and finally, specific clones are selected based on markers like antibiotic resistance genes.

157. (A) Cleave DNA at random sites far away from their recognition sequence
Type I restriction endonucleases are complex, multi-subunit enzymes that differ significantly from the more common Type II enzymes. While they recognize specific DNA sequences, they catalyze cleavage at random sites that may be several thousand base pairs away from the recognition site. This randomness, combined with their requirement for ATP, makes them unsuitable for typical gene cloning and precise DNA manipulation.

158. (C) Phosphodiester bonds between a 3'-OH and a 5'-phosphate
DNA ligases play a vital role in genetic engineering by catalyzing the formation of a covalent phosphodiester bond between the three-prime hydroxyl group of one DNA strand and the five-prime phosphate group of another. This reaction effectively seals gaps in the sugar-phosphate backbone, allowing for the stable joining of different DNA fragments. The process requires energy, typically provided by ATP.

159. (D) Complementary DNA (cDNA) from an mRNA template
Reverse transcriptase is an indispensable enzyme used in biotechnology to synthesize complementary DNA from a mature messenger RNA template. Because mRNA lacks introns, the resulting cDNA represents the actual coding sequence of a gene, which is essential for expressing eukaryotic proteins in prokaryotic hosts. This enzyme is the cornerstone of cDNA library construction and various techniques like RT-PCR for gene analysis.

160. (A) IV, I, II, III
Building a cDNA library begins with the isolation of mature mRNA, which serves as the template for genetic information. Reverse transcriptase then synthesizes the first complementary DNA strand, followed by the degradation of the original RNA template by RNase H. Finally, a second DNA strand is synthesized to create stable, double-stranded cDNA molecules that can be cloned into vectors.

161. (B) Retroviruses
Reverse transcriptase is a specialized enzyme that natively originates from retroviruses, such as HIV. Its biological role is to copy the viral RNA genome into double-stranded DNA,

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234. (A) Competitive
If an inhibitor binds solely to the free enzyme but not to the enzyme-substrate complex, the inhibition is categorized strictly as competitive. The inhibitor and the substrate compete for the same active site, meaning that the presence of one prevents the binding of the other. This type of inhibition increases the apparent Michaelis constant but does not affect the maximal reaction rate.

235. (D) Fully overcome the inhibition and achieve the original $V_{\{}\text{max}_{\}}$
Competitive inhibition can be fully overcome by increasing the substrate concentration to very high levels. Because the inhibitor and substrate compete for the same active site, an excess of substrate will eventually displace all of the inhibitor molecules. As a result, the enzyme can still reach its original maximal velocity, although it requires much more substrate to do so effectively.

236. (B) Active enzyme molecules capable of reaching $V_{\{}\text{max}_{\}}$
Non-competitive inhibition effectively reduces the pool of active enzyme molecules that are capable of reaching the maximal velocity. Since the inhibitor binds to an allosteric site and inactivates the enzyme regardless of whether the substrate is bound, increasing the substrate concentration cannot overcome the inhibition. This results in a decrease in the observed $V_{\{}\text{max}_{\}}$, even though the substrate affinity remains unaffected.

237. (A) The inhibitor requires the substrate to bind the enzyme first to create its binding site
Uncompetitive inhibition is characterized by the fact that the inhibitor binds exclusively to the enzyme-substrate complex and not to the free enzyme. This means that the binding of the substrate is a prerequisite for the inhibitor to interact with the catalyst. As a result, both the maximal velocity and the apparent Michaelis constant decrease proportionally, leading to parallel Lineweaver-Burk.

238. (C) Transpeptidase
Penicillin kills bacteria primarily by irreversibly inhibiting the enzyme transpeptidase, which is responsible for cross-linking the peptidoglycan chains in the bacterial cell wall. By acting as a suicide inhibitor, penicillin forms a stable covalent bond with the enzyme's active site, permanently blocking its function. Without a stable cell wall, the bacterium becomes susceptible to osmotic pressure and eventually undergoes lysis.

239. (D) Allosteric regulation by the final end-product
Feedback inhibition is a sophisticated metabolic control mechanism where the final end-product of a pathway acts as an allosteric inhibitor of an enzyme earlier in the sequence. By binding to a regulatory site, the end-product signals that enough of the substance has been produced, slowing down the entire pathway. This ensures that cellular resources are not wasted by overproduction throughout.

NODIA

240. (C) Cooperative binding among multiple subunits
The sigmoidal velocity curve characteristic of allosteric enzymes fundamentally indicates cooperative binding among multiple subunits. When a substrate molecule binds to one active site, it induces a conformational change that increases the affinity of the remaining sites for the substrate. This cooperativity allows the enzyme to respond very sensitively to small changes in substrate concentration, enabling precise control over metabolic flux.

241. (B) Inactive
The phosphorylation of glycogen synthase is a regulatory covalent modification that causes the enzyme to become inactive. This process is catalyzed by specific protein kinases and serves to inhibit glycogen synthesis when blood glucose levels are low or when energy is needed elsewhere. The inactivation can be reversed by phosphatases, allowing the cell to rapidly switch between storing and mobilizing glucose.

242. (D) Enterokinase (enteropeptidase)
Trypsinogen is the inactive zymogen precursor of trypsin, synthesized and secreted by the pancreas. It is converted to its active form within the small intestine by the action of enterokinase, a specialized protease located on the intestinal brush border. Once a small amount of trypsin is formed, it can auto-catalytically activate more trypsinogen, initiating a cascade of digestive enzyme activation.

298. (A) Proton acceptor
In general base catalysis, an amino acid residue functions as a proton acceptor, removing a proton from the substrate or water molecule. This generates a more reactive nucleophile that facilitates the enzymatic reaction. Amino acid residues such as histidine commonly participate in general base catalysis because they can readily accept and donate protons.

299. (B) Pantothenic acid
Coenzyme A (CoA) is synthesized from pantothenic acid (vitamin B_5) along with cysteine and adenosine derivatives. CoA plays a central role in metabolism by carrying acyl groups during reactions such as the citric acid cycle, fatty acid oxidation, and fatty acid synthesis. Pantothenic acid is therefore an essential vitamin for energy metabolism.

300. (B) ALT (SGPT) and AST (SGOT)
Alanine aminotransferase (ALT/SGPT) and aspartate aminotransferase (AST/SGOT) are key liver enzymes released into the bloodstream when hepatocytes are damaged. Markedly elevated serum ALT and AST levels are characteristic indicators of hepatitis and severe liver injury. ALT is more liver-specific, while AST is also present in cardiac and skeletal muscle.

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252. (B) ATP or NAD+
The fundamental reaction catalyzed by DNA ligase during cloning involves the formation of a phosphodiester bond, a process that requires the input of chemical energy. Depending on the source of the enzyme, this energy is derived directly from the hydrolysis of adenosine triphosphate or nicotinamide adenine dinucleotide. The energy is used to activate the five-prime phosphate group, facilitating ligation.

253. (A) RNase H activity (degrading RNA in RNA:DNA hybrids)
In retroviruses, the reverse transcriptase enzyme also exhibits critical secondary RNase H activity, which is necessary for viral replication. This activity specifically degrades the RNA strand within an RNA-DNA hybrid, allowing the enzyme to then synthesize the second DNA strand using the first as a template. Without this ability to remove the original RNA, the virus could not produce double-stranded.

254. (C) The 3' poly-A tail of eukaryotic mRNA
When synthesizing cDNA, poly-T or oligo-dT primers are typically employed because they specifically target the three-prime poly-adenosine tail found on almost all eukaryotic messenger RNA molecules. This ensures that the reverse transcriptase initiates synthesis from the end of the transcript, capturing the full coding sequence of the gene. This strategy is essential for building representative and high-quality cDNA libraries.

255. (D) $50 - 65^{\circ} C$
In a standard PCR cycle, the annealing step generally occurs within a temperature range of fifty to sixty-five degrees Celsius. This temperature is low enough to allow the short primers to form stable hydrogen bonds with their complementary sequences on the single-stranded DNA template, but high enough to prevent non-specific binding. The precise temperature is optimized based on primer properties.

256. (C) The enzyme generates PCR products with a higher error rate
Thermostable DNA polymerases like Taq typically lack three-prime to five-prime exonuclease activity, which serves as a proofreading mechanism. The direct consequence of this deficiency is that the enzyme generates PCR products with a higher error rate, as it cannot detect or correct misincorporated nucleotides. This may lead to unintended mutations in amplified DNA, a significant consideration for cloning and expression.

257. (B) Internal hydrogen bonds and stabilizing salt bridges
An enzyme that operates perfectly at ninety-five degrees Celsius maintains its folded state primarily through an increased density of internal hydrogen bonds and stabilizing salt bridges. These structural features provide the necessary rigidity to resist the high kinetic energy of extreme heat, preventing the protein from unfolding and losing its activity. Such adaptations are a hallmark of enzymes from hyperthermophilic organisms.

NODIA

258. (B) 10–20 Å
The typical diameter of an enzyme's active site ranges from ten to twenty Angstroms, occupying only a small fraction of the total protein volume. This compact microenvironment is formed by the precise folding of the polypeptide chain, bringing distant amino acid residues together. The small size ensures high specificity and provides an ideal setting for various noncovalent interactions required for catalysis.

259. (A) Naturally occurring ribozymes
The self-splicing group I introns discovered by Thomas Cech are classic examples of naturally occurring ribozymes. These RNA molecules possess intrinsic catalytic activity, allowing them to precisely excise themselves from a precursor transcript without the need for protein enzymes. This groundbreaking discovery proved that RNA can function as both a carrier of genetic information and a biocatalyst, fundamentally changing biology.

260. (B) Most enzymes have a specific optimum pH where activity is maximal
The effect of pH on enzyme activity is significant, as most enzymes possess a specific optimum pH where their catalytic rate is maximal. Changes in pH alter the ionization state of amino acid side chains within the active site, which can disrupt substrate binding or the catalytic mechanism. Beyond the optimal range, the enzyme may undergo denaturation, leading to permanent loss.

261. (C) $Q_{\{10\}}$
The $Q_{\{10\}}$ factor is a standard measure used in biochemistry to describe the sensitivity of an

2013

9. What is the approximate standard free energy of hydrolysis (ΔG°) for the terminal phosphate bond of ATP?
(A) -14.2 kJ/mol
(B) -30.5 kJ/mol
(C) -43.0 kJ/mol
(D) -61.9 kJ/mol

2023

10. Consider the following assertion and reason regarding the stability of ATP in aqueous solutions:
Assertion (A): ATP is thermodynamically unstable but kinetically stable in aqueous solutions.
Reason (R): The activation energy required to cleave the phosphoanhydride bonds of ATP is exceptionally low without enzymatic catalysis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

11. Which factor contributes most significantly to the large negative free energy of hydrolysis of ATP?
(A) Resonance stabilization of the resulting orthophosphate
(B) The hydrophobic nature of the adenine ring
(C) The highly basic properties of the ribose sugar
(D) The strong hydrogen bonding between the phosphate groups

2006

12. Phosphoenolpyruvate (PEP) is considered a high-energy compound because:
(A) It contains a highly unstable thioester bond coupled to a phosphate group
(B) It serves as the universal energy currency for all major metabolic pathways
(C) Hydrolysis is followed by rapid enol-to-keto tautomerization
(D) It facilitates the direct transfer of electrons to the respiratory chain

2009

13. Which of the following high-energy biomolecules acts as a primary energy reserve in vertebrate skeletal muscle?
(A) Phosphoenolpyruvate
(B) Acetyl-CoA
(C) 1,3-Bisphosphoglycerate
(D) Phosphocreatine

2008

14. Identify the correct statement regarding thioesters, such as Acetyl-CoA.
(A) They possess less free energy of hydrolysis compared to ordinary oxygen esters
(B) They are primarily formed in the cytosol during glycolysis
(C) They lack the resonance stabilization present in oxygen esters, making their hydrolysis highly exergonic
(D) They are synthesized exclusively in the mitochondrial matrix

2009

15. The high energy of hydrolysis of 1,3-bisphosphoglycerate is primarily utilized in which metabolic pathway?
(A) The oxidative phase of the pentose phosphate pathway
(B) Substrate-level phosphorylation during glycolysis
(C) The synthesis of essential amino acids
(D) The generation of proton motive force in the ETC

2025

16. Among the following molecules, which possesses the highest standard free energy of hydrolysis?
(A) ATP
(B) Glucose-6-phosphate
(C) Pyrophosphate
(D) Phosphoenolpyruvate

2022

17. The conversion of ADP to ATP via substrate-level phosphorylation is directly facilitated by the hydrolysis of:
(A) Succinyl-CoA
(B) Glucose-1-phosphate
(C) Fructose-1,6-bisphosphate
(D) AMP

2018

18. Why is the hydrolysis of phosphocreatine thermodynamically favored?
(A) Because it forms a stable keto tautomer under neutral physiological conditions
(B) Because the reaction is heavily dependent on a low pH matrix environment
(C) The resonance stabilization of the resulting products is much greater
(D) Because the high intracellular concentration of creatine drives the reaction

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charge stabilization is a common strategy used by metalloenzymes to accelerate reactions.

271. (D) Carboxylation
Biotin, which is derived from vitamin B_7, acts as a specialized coenzyme for the class of reactions known as carboxylations. It is covalently linked to the enzyme and functions as a flexible arm that transports an activated carboxyl group from one site to another. This mechanism is critical for the synthesis of fatty acids and the maintenance of blood glucose levels.

272. (D) The physiological intracellular concentration of the substrate
The Michaelis constant is practically useful because it provides an estimate of the physiological intracellular concentration of a substrate. For many metabolic enzymes, the K_m value is found to be close to the typical concentration of its substrate within the cell. This alignment allows the enzyme to operate in a range where its activity is highly sensitive to changes in availability.

273. (B) $0.67\,V_{\{}\mathrm{max}_{\}}$
According to the Michaelis-Menten equation, at a substrate concentration mathematically equal to two times the Michaelis constant, the initial velocity of the reaction is two-thirds, or approximately sixty-seven percent, of the maximal velocity. This relationship illustrates the hyperbolic nature of the kinetic curve, showing how the rate of reaction increases as more active sites are occupied until saturation occurs.

274. (D) The x-intercept to move closer to zero, while the y-intercept remains constant
In a Lineweaver-Burk plot, a competitive inhibitor fundamentally causes the x-intercept to move closer to zero while the y-intercept remains constant. This reflects the increase in the apparent Michaelis constant and the preservation of the original maximal velocity. The lines for different inhibitor concentrations will all intersect at the same point on the vertical axis, confirming high substrate overcomes.

275. (A) At very high substrate concentrations, because the ES complex is abundant
Uncompetitive inhibitors are most effective under conditions of high substrate concentration because they bind exclusively to the enzyme-substrate complex. As the substrate level increases, more ES complex is formed, providing more binding sites for the inhibitor. This unique property means that uncompetitive inhibition cannot be overcome by adding more substrate; in fact, increasing the substrate concentration actually enhances the inhibitory effect.

276. (C) Exhibit extreme specificity, generally only targeting the specific enzyme that attempts to process them
Suicide inhibitors are highly prized in pharmacology because they exhibit extreme specificity, generally only targeting the specific enzyme that attempts to process them. Because they are initially unreactive, they minimize off-target effects and systemic toxicity. Once activated by the enzyme's own catalytic machinery, they form a permanent covalent bond that irreversibly destroys the target's function, providing long-lasting therapeutic benefits.

277. (A) Cooperative interactions among multiple active sites
The sigmoidal velocity curve of an allosteric enzyme fundamentally implies cooperative interactions among multiple active sites within the protein complex. The binding of a substrate molecule to one site influences the affinity of the other sites, typically increasing it in the case of positive cooperativity. This mechanism allows for a switch-like response to substrate availability, which is essential for regulation.

278. (D) The enzyme does not need to be degraded and re-synthesized from scratch
Reversible covalent modifications such as phosphorylation are economically economical for the cell because the target enzyme does not need to be completely degraded and re-synthesized from scratch to change its activity. Instead, a small and relatively inexpensive chemical group is added or removed to rapidly toggle the enzyme between active and inactive states. This provides a fast means of control.

NODIA

279. (A) Catalyze exactly the same chemical reaction but usually possess different kinetic parameters
An important distinction between isoenzymes is that they catalyze exactly the same chemical reaction but usually possess different kinetic parameters, such as K_m and $V_{\{}\mathrm{max}_{\}}$. These variations allow different tissues to tailor the reaction to their specific metabolic needs and environmental conditions. This localized

enzymatic reaction to changes in temperature. It represents the factor by which the reaction rate increases for every ten-degree Celsius rise in temperature. For most biological systems, the $Q_{\{10\}}$ value is approximately two, meaning the rate doubles for each ten-degree increase within physiological temperature ranges.

262. (A) Entropy reduction (Entropy Trap)
The concept of entropy reduction, often referred to as an "entropy trap," describes how an enzyme binds its substrate to restrict its translational and rotational motion. By orienting the reactants in a fixed, optimal geometry for catalysis, the enzyme significantly increases the probability of a successful reaction. This reduction in randomness lowers the energy barrier required to reach the transition state.

263. (B) The catalytic triad (Asp, His, Ser)
Serine proteases, such as chymotrypsin and trypsin, rely heavily on a localized catalytic structure known as the catalytic triad. This triad consists of three specific amino acid residues—aspartate, histidine, and serine—that work together to facilitate the nucleophilic attack on the peptide bond. The strategic arrangement of these residues allows the enzyme to achieve high catalytic efficiency at physiological pH levels.

264. (B) Biotin
Biotin is a specialized coenzyme required by all enzymes that catalyze carboxylation reactions, where a carboxyl group is added to a substrate. It is covalently attached to the enzyme and serves as a flexible carrier of activated carbon dioxide. This process is essential for various metabolic pathways, including fatty acid synthesis and gluconeogenesis, where it helps build complex biological molecules.

265. (C) BRENDA
BRENDA is a comprehensive international database that provides detailed information on enzyme nomenclature, reactions, and kinetic properties. It serves as a vital resource for researchers, offering curated data on hundreds of thousands of enzymes across all kingdoms of life. By providing standardized information, BRENDA facilitates the study of enzymatic function and supports the development of new biotechnological and therapeutic agents.

266. (B) Glucose oxidase
Glucose oxidase is widely used in clinical settings to accurately quantify glucose levels in blood samples through a colorimetric assay. The enzyme catalyzes the oxidation of glucose, producing hydrogen peroxide as a byproduct. In a subsequent step, a peroxidase enzyme uses this peroxide to oxidize a colorless dye into a measurable colored product, allowing for the rapid monitoring of blood.

267. (C) It is the configuration of atoms with the highest potential energy along the reaction path
A key characteristic of the transition state in an enzymatic reaction is that it represents the configuration of atoms with the highest potential energy along the entire reaction path. It is a fleeting, high-energy state where bonds are partially formed and broken, and it cannot be isolated for analysis. Enzymes accelerate reactions by specifically binding and stabilizing this state.

268. (A) HMG-CoA reductase
Statins are a class of widely prescribed drugs used to lower blood cholesterol levels by acting as transition-state analogs that inhibit the enzyme HMG-CoA reductase. This enzyme catalyzes the rate-limiting step in the biosynthesis of cholesterol in the liver. By mimicking the structure of the high-energy intermediate, statins bind very tightly to the active site, effectively blocking cholesterol production.

269. (C) Serine
Within the catalytic triad of serine proteases, the serine residue acts as the essential nucleophile that directly attacks the carbonyl carbon of the peptide bond. The surrounding aspartate and histidine residues serve to activate the serine by increasing its nucleophilicity. This collaborative mechanism leads to the formation of a transient acyl-enzyme intermediate, which is a hallmark of this enzyme class.

270. (C) Stabilizes a developing negative charge in the transition state
When zinc acts catalytically in enzymes like carboxypeptidase, it generally functions by stabilizing a developing negative charge on the oxygen atom of the transition state. The metal ion acts as a powerful electrophile, polarizing the carbonyl group of the substrate and making it more susceptible to nucleophilic attack. This

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profile that can be used for identification and comparison. This high-sensitivity amplification is essential for modern criminal investigations and paternity.

289. (B) Its relatively high error rate can introduce unintended mutations
A notable drawback of the native Taq DNA polymerase when amplifying very long DNA templates is its relatively high error rate, which can introduce unintended mutations. Because Taq lacks proofreading activity, these errors accumulate during multiple cycles of PCR, potentially compromising the integrity of large genes. For these applications, researchers often switch to high-fidelity polymerases that possess exonuclease proofreading activity.

290. (D) Immunoglobulins
Abzymes mimic standard enzymes perfectly except they are fundamentally derived from immunoglobulins, which are the antibodies produced by the immune system. By engineering or selecting antibodies that bind to transition-state analogs, researchers can create biocatalysts with high specificity. This approach allows for the development of new catalysts for chemical reactions that are not natively performed by existing natural biological enzymes.

291. (A) The reactant ground state and the transition state
The free energy of activation represents the critical energy difference between the ground state of the reactants and the high-energy transition state. It defines the thermodynamic hurdle that molecules must overcome for a chemical transformation to occur. Enzymes facilitate this process by lowering this energy barrier, thereby increasing the rate at which reactants can be converted into products in systems.

292. (C) High-energy transition intermediate
In transition state stabilization, the enzyme actively forces the substrate into a specific geometry that most closely resembles the high-energy transition intermediate. By providing a microenvironment that is complementary to this state, the enzyme maximizes favorable noncovalent interactions, which releases binding energy to offset the activation barrier. This dynamic matching is a fundamental mechanism by which biocatalysts achieve immense power.

293. (A) Chiral
The remarkable stereospecificity of enzymes arises because most biological molecules, including amino acids and sugars, are inherently chiral. Because enzymes themselves are composed of chiral amino acids, their active sites are asymmetric and can distinguish between optical isomers with high precision. This ensures that cellular metabolism only produces and utilizes the correct three-dimensional forms of molecules necessary for survival and function.

294. (C) The large protein scaffold is needed to orient functional groups precisely
The active site occupies only a small portion of an enzyme because the remaining protein forms a three-dimensional scaffold that correctly positions catalytic amino acid residues. This structure stabilizes the active site, binds the substrate specifically, and facilitates efficient catalysis. The overall protein fold is therefore essential for enzyme activity, specificity, and structural stability.

295. (B) Lactate dehydrogenase
Lactate dehydrogenase (LDH) is a multimeric enzyme composed of four subunits encoded by different genes, making it an exception to the simple one-protein, one-gene concept. Different combinations of H and M subunits produce tissue-specific LDH isoenzymes with distinct physiological roles. In contrast, myoglobin, lysozyme, and ribonuclease A are single-polypeptide proteins.

296. (C) Horseradish peroxidase
Horseradish peroxidase (HRP) is widely used in ELISA because it catalyzes the oxidation of chromogenic substrates such as TMB in the presence of hydrogen peroxide, producing a measurable color change. The intensity of the color is proportional to the amount of antigen or antibody present, enabling sensitive and accurate immunological detection.

297. (B) Malathion
Malathion is an organophosphate insecticide that acts as an irreversible inhibitor of acetylcholinesterase. It forms a stable covalent bond with the enzyme, preventing the breakdown of acetylcholine and causing continuous nerve stimulation in insects. This irreversible inhibition ultimately leads to paralysis and death, making malathion an effective insecticide.

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243. (A) Fine-tuned metabolic regulation tailored to specific tissue conditions
Isoenzymes are highly advantageous to an organism because they allow for fine-tuned metabolic regulation tailored to the specific needs of different tissues. Although they catalyze the same reaction, variations in their kinetic parameters and regulatory properties ensure each organ can function optimally under unique physiological conditions. This localized specialization is essential for the overall metabolic efficiency and survival of the organism.

244. (C) CPK, AST (SGOT), and LDH
Clinicians monitor the temporal pattern of release for three key enzymes—creatine phosphokinase, aspartate aminotransferase, and lactate dehydrogenase—to diagnose and assess myocardial infarction. Following a heart attack, these enzymes leak into the blood at different rates, with CPK rising first, followed by AST and then LDH. Analyzing these trends provides information about the timing and extent of cardiac tissue damage.

245. (A) Alcoholic liver disease and biliary damage
High levels of gamma-glutamyl transferase in the blood are specifically indicative of alcoholic liver disease and biliary tract damage. GGT is a sensitive marker for alcohol-induced hepatic injury, even when other liver enzymes may still be within normal ranges. Measuring serum GGT helps clinicians identify chronic alcohol abuse and monitor the patient's liver health during the entire recovery and treatment.

246. (D) Potential loss of enzyme activity due to chemical modification of crucial residues
One distinct disadvantage of enzyme immobilization by covalent binding is the potential loss of catalytic activity due to the chemical modification of crucial amino acid residues. If a functional group involved in the active site or transition state stabilization is altered during the coupling process, the enzyme's efficiency may be significantly reduced. Careful selection of reaction conditions is required to minimize this.

247. (B) Successful stable immobilization of the biocatalyst
The successful application of enzymes in continuous stirred-tank reactors heavily depends on the stable immobilization of the biocatalyst. By confining the enzyme to a solid support or matrix, it can be easily retained within the reactor while the substrate and product stream flows through. This allows for continuous production over long periods, improving the economic feasibility of industrial enzymatic processes.

248. (C) Fructose
Glucose isomerase is a massive industrial enzyme responsible for the conversion of glucose into fructose. This isomerization step is essential for the production of high-fructose corn syrup, which is widely used as a sweetener in the food and beverage industry because fructose is significantly sweeter than glucose. The process is typically performed using immobilized enzymes in large-scale columns for efficiency.

249. (D) Protease
In the leather industry, microbial proteases are heavily utilized for the "bating" process, which serves to soften and prepare animal hides for tanning. These enzymes break down specific non-collagenous proteins, increasing the flexibility and quality of the final leather product. Using enzymatic bating provides a more controlled and environmentally friendly alternative to traditional methods that relied on harsh chemical agents.

NODIA

250. (A) 5' overhanging sticky ends
EcoRI is a widely used Type II restriction enzyme that recognizes the palindromic sequence GAATTC and cleaves it in a staggered fashion. This results in the production of five-prime overhanging sticky ends with the sequence AATT. These cohesive overhangs are invaluable in recombinant DNA technology, as they can easily base-pair with complementary sequences from other DNA fragments, facilitating efficient ligation.

251. (B) Recognize exactly the same sequence and cleave at the same positions
Isoschizomers are defined as multiple restriction endonucleases, typically isolated from different bacterial species, that recognize exactly the same DNA sequence and cleave it at the same positions. While they produce identical fragments, they may differ in their sensitivity to DNA methylation or their requirements for specific buffer conditions. These enzymes provide researchers with flexible options for engineering and analysis.

CHAPTER 05
Bioenergetics

2004

1. Which of the following best defines an exergonic reaction in biological systems?
(A) A reaction with a negative change in standard free energy
(B) A reaction with a positive change in standard free energy
(C) A reaction that requires an input of metabolic energy to proceed
(D) A reaction where the system absorbs heat from the surroundings

2001

2. The Nernst equation is primarily used to calculate which of the following parameters in a biological redox system?
(A) The activation energy of an electron transfer reaction
(B) The total heat enthalpy generated during oxidative phosphorylation
(C) The exact reduction potential at non-standard physiological conditions
(D) The absolute concentration of oxidized cytochromes in the mitochondria

2011

3. What is the fundamental role of ATP in coupling endergonic and exergonic reactions?
(A) Its hydrolysis provides the necessary free energy to drive thermodynamically unfavorable reactions
(B) It acts as a long-term storage form of biological energy
(C) It lowers the activation energy of the coupled enzymes
(D) It directly transfers electrons to the final acceptor in the metabolic pathway

2023

4. Identify the INCORRECT statement regarding standard redox potentials in biological systems.
(A) Electrons tend to flow from a system with a more negative standard reduction potential to one with a more positive standard reduction potential
(B) The standard hydrogen electrode is assigned a potential of exactly 0.0 V at pH 0
(C) Biological standard reduction potentials are typically defined at pH 7.0
(D) A highly positive redox potential indicates a strong tendency to donate electrons

2019

5. In biological thermodynamics, the standard free energy change (ΔG°) is most directly proportional to which variable?
(A) The total concentration of all enzymes in the system
(B) The natural logarithm of the equilibrium constant
(C) The atmospheric pressure surrounding the organism
(D) The rate constant of the forward reaction

2006

6. Which metabolic scenario best illustrates the concept of thermodynamic coupling?
(A) The spontaneous breakdown of hydrogen peroxide by catalase
(B) The diffusion of oxygen across the alveolar membrane
(C) The phosphorylation of glucose to glucose-6-phosphate driven by ATP hydrolysis
(D) The transport of water through aquaporin channels

2019

7. According to thermodynamic principles, for a metabolic pathway to proceed in the forward direction, the overall change in free energy must be:
(A) Exactly zero to maintain homeostasis
(B) Positive, indicating energy absorption
(C) Dependent solely on the concentration of the final product
(D) Negative, indicating the process is exergonic

2013

8. Which of the following electron carriers possesses the most negative standard reduction potential?
(A) NAD+ / NADH
(B) Ubiquinone (CoQ)
(C) Cytochrome c
(D) FAD / FADH2

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specialization is achieved through subtle structural differences, although the fundamental catalytic mechanism remains consistent across all forms.

280. (C) Acute myocardial infarction
Measuring serum levels of the CPK-MB isoenzyme is critical in the acute diagnosis of myocardial infarction. Because this specific form of creatine phosphokinase is found predominantly in heart muscle cells, its appearance in the blood is a strong indicator of cardiac tissue damage. Clinicians use the rise and fall of CPK-MB levels to confirm a heart attack and determine severity.

281. (D) Adsorption or covalent attachment
The immobilization of an enzyme onto a solid non-porous support surface relies heavily on either physical adsorption or covalent attachment. In these methods, the enzyme is fixed to the surface of a material like glass beads or plastic films, which keeps it localized while allowing for easy recovery. While adsorption is simpler, covalent attachment provides a more secure bond for reactors.

282. (A) Substrate molecules struggle to diffuse rapidly to the active site
The mass transfer resistance often observed in immobilized enzyme systems implies that substrate molecules struggle to diffuse rapidly from the bulk liquid to the active sites sequestered within a matrix. This diffusion limitation can significantly reduce the overall reaction rate, making the catalyst appear less efficient than its free-form counterpart. Understanding and minimizing these effects is a primary challenge in engineering.

283. (C) Glucose isomerase
In the commercial production of high-fructose corn syrup, the enzyme glucose isomerase is responsible for the final conversion step. It catalyzes the isomerization of glucose, produced from starch hydrolysis, into fructose. This step is vital because fructose has a higher sweetness than glucose, making the final syrup more valuable for food and beverage applications. The reaction is typically performed continuously.

284. (A) The presence of bleach, high pH, and surfactants
Alkaline proteases added to modern laundry detergents must successfully withstand environmental challenges, including high pH levels, the presence of oxidative bleaching agents, and the disruptive effects of surfactants. These enzymes are either naturally robust or genetically engineered to maintain their structure and activity under these harsh conditions. Their resilience ensures the effective removal of protein-based stains during the washing cycle.

285. (A) They possess perfectly compatible cohesive (or blunt) ends for ligation
In recombinant DNA technology, cloning vectors and insert DNA are typically digested with the same Type II restriction endonuclease to ensure they possess perfectly compatible ends for ligation. By using the same enzyme, the overhanging sticky ends on both fragments will be exactly complementary, allowing them to hydrogen-bond and then be covalently joined by DNA ligase to form stable DNA.

286. (B) Their complementary overhangs hydrogen-bond, stabilizing the interaction for ligase
Restriction fragments generated with "sticky ends" are preferred in standard cloning primarily because their complementary single-stranded overhangs can hydrogen-bond with each other. This temporary pairing stabilizes the interaction between the two DNA molecules, providing enough time for DNA ligase to form the permanent covalent phosphodiester bonds. This makes the overall cloning process significantly more efficient than using fragments with blunt ends.

NODIA

287. (D) Reverse transcriptase
When setting up a typical PCR amplification reaction for DNA, several components are strictly necessary, including the target DNA template, a thermostable DNA polymerase, and deoxynucleotide triphosphates. However, reverse transcriptase is not required unless the starting material is RNA, as in the case of RT-PCR. For standard DNA amplification, the polymerase itself is sufficient to synthesize the new complementary strands.

288. (D) Short tandem repeats (STRs) or specific loci
In forensic DNA analysis, standard PCR utilizes thermostable polymerases primarily to amplify short tandem repeats or other specific genetic loci from small or degraded samples. By creating millions of copies of these variable regions, investigators can generate a unique DNA

2005

19. What is the structural basis for the high-energy nature of the phosphoanhydride bonds in ATP?
(A) Strong electrostatic repulsion between the negatively charged oxygen atoms at physiological pH
(B) The lack of any resonance structures in the ATP molecule
(C) The planar geometry of the adenine base
(D) The specific binding of magnesium ions to the ribose hydroxyl groups

2012

20. Consider the following match of electron transport chain complexes and their specific prosthetic groups:
List I: (Complexes)
P. Complex I
Q. Complex II
R. Complex III
S. Complex IV
List II: (Prosthetic Groups)
1. Heme a and a3, Cu centers
2. FMN, Fe-S clusters
3. FAD, Fe-S clusters
4. Heme b, Heme c1, Fe-S clusters
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-4, R-3, S-1
(D) P-4, Q-3, R-2, S-1

2013

21. Which complex of the electron transport chain does NOT pump protons across the inner mitochondrial membrane?
(A) Complex I
(B) Complex II
(C) Complex III
(D) Complex IV

2015

22. What is the precise function of Cytochrome c in the electron transport chain?
(A) To transfer electrons from Complex I to Complex III
(B) To act as the final electron acceptor
(C) To shuttle electrons between Complex III and Complex IV
(D) To directly synthesize ATP in the intermembrane space

2003

23. Identify the specific inhibitor of Complex III (Cytochrome bc1 complex).
(A) Rotenone
(B) Cyanide
(C) Oligomycin
(D) Antimycin A

2009

24. How many electrons are required to fully reduce one molecule of oxygen (O_2) to two molecules of water at Complex IV?
(A) 1
(B) 2
(C) 4
(D) 8

2005

25. Which of the following electron carriers is highly lipid-soluble and freely mobile within the inner mitochondrial membrane?
(A) Cytochrome c
(B) Ubiquinone (Coenzyme Q)
(C) FMN
(D) Rieske iron-sulfur protein

2002

26. The Q-cycle operates specifically at which site in the electron transport chain?
(A) NADH-Q oxidoreductase
(B) Q-cytochrome c oxidoreductase
(C) Succinate-Q reductase
(D) Cytochrome c oxidase

2008

27. Carbon monoxide (CO) exerts its toxic effect on cellular respiration primarily by binding to:
(A) The reduced form of Cytochrome a3 in Complex IV
(B) Complex I
(C) The F_1 subunit of ATP synthase
(D) The oxidized form of Cytochrome c

2002

28. Which component of Complex I serves as the initial electron acceptor from NADH?
(A) Iron-sulfur clusters
(B) FAD
(C) FMN
(D) Ubiquinone

2023

29. What is the net consequence of the Q-cycle during the transfer of electrons through Complex III?
(A) Two electrons are directly transferred to oxygen atoms
(B) One molecule of ATP is synthesized by substrate level
(C) NADH is regenerated for use in the TCA cycle reactions

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2013

71. How does reciprocal regulation of glycogen metabolism occur via cAMP-dependent pathways?
(A) PKA phosphorylation activates both glycogen synthase and glycogen phosphorylase
(B) cAMP directly binds and inhibits glycogen phosphorylase
(C) cAMP dephosphorylates glycogen synthase to activate it
(D) PKA phosphorylation inactivates glycogen synthase and activates glycogen phosphorylase

2025

72. Which protein phosphatase is primarily responsible for reversing the cAMP-dependent phosphorylation of glycogen metabolizing enzymes?
(A) Protein Phosphatase 1 (PP1)
(B) Calcineurin
(C) PTEN
(D) Tyrosine phosphatase

2015

73. What is the role of the debranching enzyme in glycogenolysis?
(A) It solely transfers a block of three glucose residues to the end of the chain
(B) It exhibits bifunctional transferase and alpha-1,6-glucosidase activity
(C) It solely hydrolyzes the alpha-1,6-linked branch point glucose using water
(D) It rapidly cleaves all alpha-1,4 linkages located at the branch point site

2009

74. Fatty acid activation occurs primarily in the cytosol and is catalyzed by:
(A) Carnitine palmitoyltransferase I
(B) Fatty acyl-CoA synthetase (Thiokinase)
(C) Hormone-sensitive lipase
(D) Acetyl-CoA carboxylase

2003

75. The transport of long-chain fatty acyl-CoA into the mitochondrial matrix strictly requires which shuttle system?
(A) Carnitine shuttle
(B) Malate-aspartate shuttle
(C) Glycerol-3-phosphate shuttle
(D) Citrate-pyruvate shuttle

2021

76. Which step of mitochondrial beta-oxidation generates FADH2?
(A) Hydration by enoyl-CoA hydratase
(B) Oxidation by L-3-hydroxyacyl-CoA dehydrogenase
(C) Oxidation by acyl-CoA dehydrogenase
(D) Cleavage by beta-ketothiolase

2019

77. The end product of beta-oxidation of an odd-chain fatty acid is:
(A) Only Acetyl-CoA
(B) Acetyl-CoA and one molecule of Malonyl-CoA
(C) Only Propionyl-CoA
(D) Acetyl-CoA and one molecule of Propionyl-CoA

2014

78. Oxidation of unsaturated fatty acids containing cis-double bonds requires an additional enzyme to convert them to trans-double bonds. This enzyme is:
(A) 2,4-dienoyl-CoA reductase
(B) Epimerase
(C) Enoyl-CoA isomerase
(D) Desaturase

2002

79. The total theoretical ATP yield from the complete beta-oxidation of palmitic acid (16:0) and subsequent TCA cycle oxidation is approximately:
(A) 36 ATP
(B) 90 ATP
(C) 106 ATP
(D) 129 ATP

NODIA

2009

80. Consider the following match of enzymes of lipid metabolism and their corresponding pathways or functions:
List I: (Enzymes of Lipid Metabolism)
P. Acetyl-CoA carboxylase
Q. Acyl-CoA dehydrogenase
R. Carnitine palmitoyltransferase I
S. Hormone-sensitive lipase
List II: (Pathways or Functions)
1. Mitochondrial beta-oxidation
2. Fatty acid transport into mitochondria
3. Lipolysis in adipose tissue
4. Committed step of fatty acid synthesis
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-2, S-4

(C) The direct transfer of a proton onto the ATP molecule
(D) Rotation of gamma inducing conformational changes in beta

2024

40. Consider the following statements regarding glycolysis:
I. Hexokinase undergoes a major conformational change upon glucose binding.
II. Phosphofructokinase-1 (PFK-1) catalyzes a reversible reaction.
III. Aldolase cleaves a 6-carbon sugar into two identical 3-carbon sugars.
IV. Pyruvate kinase catalyzes the second substrate-level phosphorylation step.
Which of the above statement(s) is/are correct?
(A) I and III
(B) II and IV
(C) I and IV
(D) II, III and IV

2008

41. Which of the following is the most crucial rate-limiting and committed step in glycolysis?
(A) Hexokinase
(B) Phosphofructokinase-1 (PFK-1)
(C) Phosphoglucose isomerase
(D) Pyruvate kinase

2019

42. How is Phosphofructokinase-1 (PFK-1) allosterically regulated?
(A) Activated by ATP and inhibited by AMP
(B) Activated by AMP and inhibited by ATP and citrate
(C) Inhibited by fructose-2,6-bisphosphate
(D) Activated by NADH and inhibited by NAD+

2006

43. During strenuous exercise, lactate produced in the muscle is transported to the liver for gluconeogenesis. This metabolic inter-organ pathway is known as:
(A) The Cori cycle
(B) The Krebs cycle
(C) The Cahill cycle
(D) The Glyoxylate cycle

2013

44. Which enzyme allows the liver to bypass the hexokinase reaction during gluconeogenesis?
(A) Glucokinase
(B) Fructose-1,6-bisphosphatase
(C) Glucose-6-phosphatase
(D) Pyruvate carboxylase

2003

45. The conversion of pyruvate to phosphoenolpyruvate (PEP) in gluconeogenesis requires two enzymes. These are:
(A) Pyruvate kinase and PEP carboxykinase
(B) Pyruvate dehydrogenase and enolase
(C) Malic enzyme and pyruvate carboxylase
(D) Pyruvate carboxylase and PEP carboxykinase

2003

46. Consider the following statements regarding the hormonal regulation of glycolysis and gluconeogenesis by the bifunctional enzyme PFK-2/FBPase-2:
Under glucagon stimulation, which of the following occurs?
(A) PFK-2 is dephosphorylated and fully active in the cytosol
(B) Glycolysis is strongly stimulated in the hepatic tissue
(C) FBPase-2 is phosphorylated, reducing F-2,6-BP levels
(D) PFK-1 is allosterically activated by hepatic metabolites

2007

47. Which step in glycolysis generates NADH?
(A) Enolase
(B) Glyceraldehyde-3-phosphate dehydrogenase
(C) Phosphoglycerate kinase
(D) Pyruvate kinase

2011

48. Identify the INCORRECT statement regarding Hexokinase and Glucokinase.
(A) Glucokinase has a higher Km for glucose than Hexokinase
(B) Hexokinase is inhibited by its product, glucose-6-phosphate
(C) Hexokinase exhibits broad specificity for hexoses
(D) Glucokinase is exclusively expressed in skeletal muscle

2006

49. What is the net yield of ATP from one molecule of glucose undergoing glycolysis under anaerobic conditions?
(A) 2 ATP
(B) 4 ATP
(C) 32 ATP
(D) 36 ATP

2017

50. Consider the following statements about the Pyruvate Dehydrogenase (PDH) complex:

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(D) Biotin

2011

115. In transamination, which alpha-keto acid typically acts as the predominant acceptor of amino groups, forming glutamate?
(A) Pyruvate
(B) Oxaloacetate
(C) Alpha-ketoglutarate
(D) Acetoacetate

2025

116. Consider the following assertion and reason regarding the mechanism of pyridoxal phosphate:
Assertion (A): Pyridoxal phosphate functions by forming a Schiff base intermediate with the amino acid substrate.
Reason (R): The Schiff base structure serves as an electron sink to stabilize the reaction intermediates.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

117. Oxidative deamination in the liver is principally catalyzed by:
(A) Glutamate dehydrogenase
(B) Aspartate aminotransferase
(C) Glutamine synthetase
(D) Alanine aminotransferase

2013

118. Glutamate dehydrogenase is unique among enzymes because it can utilize:
(A) Only NAD+ as a coenzyme
(B) Either NAD+ or NADP+ as a coenzyme
(C) Only NADP+ as a coenzyme
(D) FAD exclusively

2008

119. How is ammonia predominantly transported from extrahepatic tissues to the liver in a non-toxic form?
(A) As free ammonium ions in the plasma
(B) As urea
(C) As glutamine
(D) As uric acid

2022

120. In skeletal muscle, excess amino groups are largely exported to the liver for urea synthesis in the form of:
(A) Glutamine
(B) Asparagine
(C) Serine
(D) Alanine

2008

121. The glucose-alanine cycle fundamentally serves to:
(A) Transport nitrogen to the liver and supply skeletons for gluconeogenesis
(B) Generate direct ATP within the muscle during periods of hypoxia
(C) Synthesize essential amino acids required for protein turnover
(D) Excrete urea directly from the muscle without liver involvement

NODIA

2022

122. Glutaminase acts in the liver to:
(A) Synthesize glutamine from glutamate and ammonia
(B) Hydrolyze glutamine to yield glutamate and free ammonia for the urea cycle
(C) Transfer the amino group from glutamine to pyruvate
(D) Convert glutamate to alpha-ketoglutarate

2019

123. The Urea Cycle occurs exclusively in which organ?
(A) Kidneys
(B) Liver
(C) Brain
(D) Skeletal muscle

2017

124. The first and rate-limiting step of the Urea Cycle is catalyzed by:
(A) Carbamoyl phosphate synthetase I
(B) Ornithine transcarbamylase
(C) Argininosuccinate synthetase
(D) Arginase

2005

125. In which subcellular compartments do the reactions of the urea cycle occur?
(A) Exclusively in the mitochondria
(B) Exclusively in the cytosol
(C) Initial mitochondrial reactions followed by completion in the cytosol
(D) Initial cytosol reactions followed by completion in the mitochondria

2005

126. Carbamoyl phosphate synthetase I requires which compound as an obligate allosteric activator?

2001

61. What is the physiological significance of cytosolic NADPH produced by the pentose phosphate pathway in erythrocytes?
(A) It provides the chemical energy required for the sodium-potassium pump
(B) It acts as a primary reducing substrate for mitochondrial ATP synthesis
(C) It promotes the rapid formation of methemoglobin in the plasma
(D) It maintains glutathione in a reduced state to combat oxidative stress

2012

62. In the non-oxidative phase of the pentose phosphate pathway, transketolase transfers a carbon fragment of what length?
(A) 1 carbon
(B) 2 carbons
(C) 3 carbons
(D) 4 carbons

2023

63. Which coenzyme is strictly required for the activity of transketolase?
(A) Pyridoxal phosphate (PLP)
(B) Thiamine pyrophosphate (TPP)
(C) Biotin
(D) Lipoamide

2013

64. Consider the following assertion and reason regarding the pentose phosphate pathway in dividing cells:
Assertion (A): Rapidly dividing cells require a highly active pentose phosphate pathway.
Reason (R): The pathway provides Ribose-5-phosphate essential for nucleotide biosynthesis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

65. If a cell requires substantially more NADPH than Ribose-5-phosphate, how does the pentose phosphate pathway adapt?
(A) The non-oxidative phase channels sugar phosphates back into glycolysis for complete oxidation
(B) The oxidative phase reverses its direction
(C) Transaldolase generates excess ribose which is excreted
(D) Glucose-6-phosphate dehydrogenase is strongly inhibited

2006

66. Glycogenin functions in glycogen metabolism by acting as a:
(A) Highly specific debranching enzyme within the muscle cytosol
(B) Selective transporter of UDP-glucose into the mitochondrial matrix
(C) Autocatalytic primer initiating the first glucose polymer chains
(D) Negative allosteric regulator of muscle glycogen phosphorylase

NODIA

2013

67. The active form of the glucose donor required for glycogen synthesis (glycogenesis) is:
(A) UDP-glucose
(B) Glucose-1-phosphate
(C) ADP-glucose
(D) CDP-glucose

2013

68. Which enzyme catalyzes the formation of alpha-1,6-glycosidic linkages in glycogen?
(A) Glycogen synthase
(B) Glycogen phosphorylase
(C) Amylo-alpha-1,6-glucosidase (Debranching enzyme)
(D) Amylo-(1,4 to 1,6)-transglycosylase (Branching enzyme)

2016

69. During glycogenolysis, the enzyme glycogen phosphorylase cleaves alpha-1,4-glycosidic bonds to release:
(A) Free glucose
(B) Glucose-1-phosphate
(C) Glucose-6-phosphate
(D) Maltose

2016

70. Consider the following assertion and reason regarding the contribution of muscle tissue to blood glucose:
Assertion (A): Muscle tissue cannot contribute directly to blood glucose levels during fasting.
Reason (R): Muscle tissue lacks the enzyme glucose-6-phosphatase.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

I. It catalyzes an irreversible oxidative decarboxylation.
II. Thiamine pyrophosphate (TPP) is a required coenzyme.
III. It is activated by high ratios of ATP/ADP.
IV. Lipoic acid acts as an acyl group carrier.
V. It connects glycolysis to the Citric Acid Cycle.

Which of the above statement(s) is/are correct?
(A) I, II, III, IV
(B) I, II, IV, V
(C) II, III, IV, V
(D) I, III, IV, V

2014

51. The Pyruvate Dehydrogenase complex is inhibited by:
(A) High levels of Acetyl-CoA and NADH
(B) High levels of Pyruvate
(C) High levels of NAD+
(D) High levels of AMP

2008

52. Which enzyme of the Citric Acid Cycle catalyzes the only substrate-level phosphorylation event?
(A) Isocitrate dehydrogenase
(B) Alpha-ketoglutarate dehydrogenase
(C) Malate dehydrogenase
(D) Succinyl-CoA synthetase

2021

53. The anaplerotic reaction catalyzed by pyruvate carboxylase replenishes which essential intermediate of the TCA cycle?
(A) Succinyl-CoA
(B) Oxaloacetate
(C) Alpha-ketoglutarate
(D) Citrate

2025

54. Which reaction in the Citric Acid Cycle is highly endergonic under standard conditions but driven forward by the rapid utilization of its product?
(A) Synthesis of citrate
(B) Decarboxylation of isocitrate
(C) Oxidation of malate to oxaloacetate
(D) Conversion of succinate to fumarate

2024

55. Fluorocitrate is a potent inhibitor of which enzyme in the TCA cycle?
(A) Citrate synthase
(B) Fumarase
(C) Succinate dehydrogenase
(D) Aconitase

2003

56. What is the total net yield of high-energy phosphate bonds (ATP/GTP) from the complete oxidation of one molecule of acetyl-CoA in the TCA cycle and subsequent oxidative phosphorylation?
(A) 10
(B) 12
(C) 15
(D) 24

2002

57. Which TCA cycle enzyme is physically embedded in the inner mitochondrial membrane and also functions as Complex II of the ETC?
(A) Malate dehydrogenase
(B) Succinate dehydrogenase
(C) Isocitrate dehydrogenase
(D) Alpha-ketoglutarate dehydrogenase

2018

58. The oxidative phase of the pentose phosphate pathway produces two primary products. What are they?
(A) NADH and Ribose-5-phosphate
(B) NADPH and Ribose-5-phosphate
(C) FADH2 and Xylulose-5-phosphate
(D) ATP and Sedoheptulose-7-phosphate

2003

59. Which enzyme catalyzes the rate-limiting step of the Pentose Phosphate Pathway?
(A) Glucose-6-phosphate dehydrogenase
(B) Transketolase
(C) Transaldolase
(D) 6-phosphogluconate dehydrogenase

2011

60. Select the correct sequence of intermediates in the oxidative phase of the Pentose Phosphate Pathway:
(A) Glucose-6-phosphate → 6-phosphoglucono-delta-lactone → 6-phosphogluconate → Ribulose-5-phosphate
(B) Glucose-6-phosphate → 6-phosphogluconate → 6-phosphoglucono-delta-lactone → Ribulose-5-phosphate
(C) Glucose-6-phosphate → Ribulose-5-phosphate → 6-phosphogluconate → Ribose-5-phosphate
(D) Glucose-6-phosphate → 6-phosphoglucono-delta-lactone → Ribulose-5-phosphate → 6-phosphogluconate

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2013

81. In what cellular compartment does de novo fatty acid biosynthesis primarily occur?
(A) Cytosol
(B) Mitochondrial matrix
(C) Endoplasmic reticulum
(D) Lysosomes

2011

82. What is the immediate direct carbon donor for the elongation steps during fatty acid synthesis?
(A) Acetyl-CoA
(B) Succinyl-CoA
(C) Malonyl-CoA
(D) Propionyl-CoA

2007

83. The multienzyme complex Fatty Acid Synthase (FAS) produces which saturated fatty acid as its primary final product?
(A) Palmitic acid (16:0)
(B) Stearic acid (18:0)
(C) Arachidic acid (20:0)
(D) Myristic acid (14:0)

2024

84. Which vitamin serves as a crucial coenzyme for Acetyl-CoA carboxylase?
(A) Thiamine
(B) Riboflavin
(C) Cobalamin
(D) Biotin

2021

85. Acetyl-CoA carboxylase is allosterically activated by:
(A) Palmitoyl-CoA
(B) Citrate
(C) Malonyl-CoA
(D) AMP

2024

86. How are reducing equivalents supplied for cytosolic lipogenesis?
(A) Via NADH generated from the early stages of glycolysis
(B) Via FADH2 originating from the mitochondrial TCA cycle
(C) Via NADPH from the pentose phosphate pathway and malic enzyme
(D) Via FMNH2 produced during the electron transport chain

2017

87. Mammals cannot introduce double bonds into fatty acid chains beyond which carbon atom?
(A) Carbon 6
(B) Carbon 9
(C) Carbon 12
(D) Carbon 15

2018

88. The acyl carrier protein (ACP) involved in fatty acid synthesis contains a prosthetic group derived from which vitamin?
(A) Pantothenic acid
(B) Niacin
(C) Folic acid
(D) Pyridoxine

2005

89. Which of the following volatile fatty acids (VFAs) is the primary precursor for gluconeogenesis in ruminants?
(A) Acetate
(B) Propionate
(C) Butyrate
(D) Valerate

NODIA

2014

90. Consider the following statements regarding ruminant metabolism:
I. Acetate is primarily utilized for lipogenesis in mammary tissue.
II. Butyrate is largely converted to beta-hydroxybutyrate in the rumen epithelium.
III. Propionate enters the TCA cycle via succinyl-CoA.
IV. The majority of blood glucose in ruminants is derived directly from dietary absorption.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I, III and IV

2023

91. In ruminants, acetate absorbed from the rumen is activated to Acetyl-CoA in peripheral tissues. Why cannot acetate be used for net synthesis of glucose?
(A) Both carbons entering the cycle are lost as CO_2 during decarboxylation
(B) It is physically unable to enter the mitochondria from the cytosol
(C) The pyruvate dehydrogenase reaction is highly active in the reverse
(D) Ruminants lack the enzyme acetyl-CoA synthetase in their hepatic tissue

2004

92. What dictates the molar ratio of volatile fatty acids (Acetate : Propionate : Butyrate) produced in the rumen?
(A) The physical temperature of the rumen
(B) The concentration of atmospheric oxygen ingested
(C) The nature of the diet (roughage vs. concentrate ratio)
(D) The amount of urea recycled via saliva

2009

93. A high-concentrate diet in a lactating dairy cow typically leads to an increase in the ruminal production of:
(A) Acetate
(B) Methane
(C) Ammonia
(D) Propionate

2006

94. The conversion of propionate to methylmalonyl-CoA in the gluconeogenic pathway requires a specific cofactor derived from:
(A) Vitamin B_{12}
(B) Biotin
(C) Vitamin B_6
(D) Both Biotin and Vitamin B_{12}

2024

95. What is the metabolic significance of beta-hydroxybutyrate produced by the rumen wall?
(A) It functions as a precursor for liver glycogen
(B) It acts as a primary energy substrate for the heart and skeletal muscle
(C) It strongly inhibits ruminal fermentation
(D) It directly enters the pentose phosphate pathway

2025

96. Under which condition does ketogenesis primarily occur in the liver?
(A) When dietary carbohydrate intake is excessively high in the rumen
(B) When insulin levels are extremely elevated in the general circulation
(C) During active fatty acid synthesis occurring in the well-fed state
(D) When beta-oxidation produces acetyl-CoA faster than TCA cycle capacity

2010

97. Which of the following is NOT classically considered a ketone body?
(A) Alpha-ketoglutarate
(B) Acetoacetate
(C) Beta-hydroxybutyrate
(D) Acetone

2010

98. The rate-limiting enzyme for hepatic ketogenesis is:
(A) HMG-CoA reductase
(B) Thiolase
(C) HMG-CoA synthase
(D) Acetoacetate decarboxylase

2013

99. Why cannot the liver utilize ketone bodies for its own energy needs?
(A) It lacks the enzyme beta-ketoacyl-CoA transferase (thiophorase)
(B) It lacks the enzyme HMG-CoA lyase
(C) Ketone bodies rapidly diffuse out of the hepatocytes due to high permeability
(D) The high concentration of glucose in the liver inhibits their utilization

2015

100. Clinical ketosis in high-yielding dairy cows is fundamentally driven by:
(A) Overfeeding of protein-rich concentrates during the early dry period
(B) A chronic deficiency in dietary saturated fats in the lactation ration
(C) Elevated levels of circulating insulin in the general blood supply
(D) Persistent negative energy balance requiring massive lipid mobilization

2021

101. Which volatile fatty acid serves as a highly ketogenic precursor in ruminants when fermented in large amounts?
(A) Propionate
(B) Butyrate
(C) Acetate
(D) Isovalerate

2007

102. In extrahepatic tissues, the utilization of acetoacetate requires its activation to acetoacetyl-CoA. The CoA donor for this reaction is:
(A) Acetyl-CoA
(B) Malonyl-CoA
(C) Succinyl-CoA
(D) Propionyl-CoA

2024

103. Arrange the following steps of cholesterol biosynthesis in the correct sequential order:
I. Squalene synthesis

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II. Mevalonate synthesis
III. Formation of HMG-CoA
IV. Cyclization to lanosterol
(A) III, II, I, IV
(B) II, III, I, IV
(C) III, I, II, IV
(D) I, III, II, IV

2025

104. The committed and rate-limiting step in de novo cholesterol biosynthesis is catalyzed by:
(A) HMG-CoA reductase
(B) HMG-CoA synthase
(C) Squalene epoxidase
(D) Mevalonate kinase

2006

105. HMG-CoA reductase is highly regulated. Which of the following conditions inhibits its activity?
(A) High intracellular levels of cholesterol
(B) High intracellular levels of insulin
(C) Abundant levels of intracellular ATP
(D) Covalent modification by protein phosphatase 1

2021

106. The isoprenoid pathway synthesizes intermediates that serve as precursors for which of the following?
(A) Glycogen
(B) Ubiquinone (Coenzyme Q)
(C) Sialic acid
(D) Carnitine

2014

107. Which molecule serves as the principal building block for the synthesis of complex phosphoglycerides?
(A) Sphingosine
(B) Phosphatidate
(C) Ceramide
(D) Malonyl-CoA

2003

108. The synthesis of sphingolipids begins with the condensation of palmitoyl-CoA and which amino acid?
(A) Serine
(B) Glycine
(C) Tyrosine
(D) Glutamate

2017

109. What defines a ceramide structurally?
(A) A glycerol backbone linked to three fatty acids via ester bonds
(B) A phosphatidic acid linked to a choline head group by phosphate
(C) Sphingosine backbone linked to a fatty acid through an amide bond
(D) A cholesterol molecule esterified to a long-chain fatty acid chain

2015

110. Arrange the sequence of intermediates in the biosynthesis of phosphatidylcholine:
I. CDP-choline
II. Choline
III. Phosphocholine
IV. Phosphatidylcholine
(A) II, III, I, IV
(B) II, I, III, IV
(C) I, II, III, IV
(D) III, II, I, IV

2009

111. Which phospholipid plays a crucial structural role in the inner mitochondrial membrane and is required for optimal function of the ETC?
(A) Phosphatidylinositol
(B) Sphingomyelin
(C) Phosphatidylserine
(D) Cardiolipin

2018

112. Dipalmitoylphosphatidylcholine (DPPC) is physiologically essential as the primary component of:
(A) Mitochondrial membranes
(B) Pulmonary surfactant
(C) Myelin sheaths
(D) Bile salts

2011

113. Transamination reactions represent the first step in the catabolism of most amino acids. What is the fundamental mechanism?
(A) Irreversible removal of an alpha-amino group as free ammonia
(B) Direct oxidation of the amino acid to yield ATP
(C) Hydrolysis of the peptide bond
(D) Reversible transfer of an alpha-amino group to an alpha-keto acid

2021

114. All known aminotransferases require a specific prosthetic group tightly bound to the enzyme. This group is:
(A) Pyridoxal phosphate (PLP)
(B) Thiamine pyrophosphate
(C) Tetrahydrofolate

NODIA

(D) Four protons are translocated for every two electrons moved

2006

30. Consider the following statements regarding the Mitchell's chemiosmotic hypothesis:

I. An intact inner mitochondrial membrane is strictly required.

II. Electron transport directly phosphorylates ADP to ATP.

III. The electrochemical gradient consists of both a chemical pH gradient and an electrical potential.

Which of the above statement(s) is/are correct?

(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2017

31. The proton motive force generated across the inner mitochondrial membrane is composed of:

(A) Only a concentration gradient of protons
(B) Both a pH gradient and a transmembrane electrical potential
(C) Only an electrical membrane potential
(D) A sodium ion gradient and a chloride ion gradient

2010

32. What is the primary function of the Fo portion of the mitochondrial ATP synthase?

(A) It catalyzes the formation of the phosphoanhydride bond between ADP and Pi
(B) It acts as an electron carrier between Complex III and Complex IV
(C) It regulates the binding of uncoupling proteins within the matrix
(D) It acts as a transmembrane proton channel into the matrix

2014

33. Which component of the F_1 portion of ATP synthase contains the catalytic site for ATP synthesis?

(A) Beta subunit
(B) Alpha subunit
(C) Gamma subunit
(D) Epsilon subunit

2023

34. What is the generally accepted mechanistic explanation for the rotation of the gamma subunit in ATP synthase?

(A) Direct energy transfer from substrate-level phosphorylation
(B) Continuous electron transfer from NADH to the alpha subunits
(C) Binding-change mechanism driven by proton flow through the c-ring
(D) Spontaneous hydrolysis of GTP within the intermembrane space

2004

35. The presence of a chemical uncoupler like 2,4-dinitrophenol (DNP) results in:

(A) Continuation of electron transport with the dissipation of energy as heat
(B) Cessation of electron transport
(C) Increased ATP synthesis
(D) Inhibition of the TCA cycle

2015

36. What is the consensus P/O ratio for the oxidation of one molecule of NADH via the mitochondrial electron transport chain?

(A) 1.5
(B) 2.5
(C) 3.0
(D) 4.0

2001

37. Which of the following compounds specifically inhibits ATP synthase by binding to the Fo subunit?

(A) Rotenone
(B) Oligomycin
(C) Antimycin A
(D) Malonate

2004

38. Thermogenin (UCP1) is an uncoupling protein physiologically expressed in brown adipose tissue to:

(A) Generate ATP under extreme cold stress conditions
(B) Prevent reactive oxygen species formation in the liver
(C) Dissipate the proton gradient to drive thermogenesis
(D) Facilitate lipid transport into the mitochondrial matrix

2014

39. According to the binding-change mechanism of ATP synthase, what dictates the release of newly synthesized ATP?

(A) The binding of a magnesium ion to the alpha subunit
(B) The high concentration of mitochondrial ADP residues

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(A) Acetyl-CoA
(B) ATP
(C) Citrulline
(D) N-acetylglutamate

2017

127. The two nitrogen atoms present in a urea molecule are derived directly from:
(A) Two molecules of free ammonia
(B) Glutamate and glutamine
(C) Free ammonia and aspartate
(D) Carbamoyl phosphate and ornithine

2007

128. The cleavage of argininosuccinate yields arginine and which TCA cycle intermediate?
(A) Malate
(B) Fumarate
(C) Succinate
(D) Oxaloacetate

2024

129. How many high-energy phosphate bonds are consumed for the synthesis of one molecule of urea?
(A) 2
(B) 3
(C) 4
(D) 5

2006

130. Consider the following assertion and reason regarding the metabolic linkage between the urea cycle and the TCA cycle:
Assertion (A): The urea cycle and the TCA cycle are metabolically linked.
Reason (R): Fumarate produced in the urea cycle can be converted to malate, which enters the mitochondria and participates in the TCA cycle.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

131. Which enzyme catalyzes the final step of the urea cycle, hydrolyzing arginine to yield urea and ornithine?
(A) Argininosuccinate lyase
(B) Ornithine transcarbamylase
(C) Arginase
(D) Urease

2013

132. The carbon atom in the urea molecule originates from:
(A) Carbon dioxide (as bicarbonate)
(B) Aspartate
(C) Acetyl-CoA
(D) Glucose

2009

133. Non-essential amino acids are so named because:
(A) They are not required for protein synthesis
(B) They lack an alpha-amino group
(C) They do not possess a genetic codon
(D) They can be synthesized endogenously by the organism

2017

134. Which glycolytic intermediate serves as the direct precursor for the biosynthesis of serine?
(A) Pyruvate
(B) 3-Phosphoglycerate
(C) Phosphoenolpyruvate
(D) Fructose-6-phosphate

2019

135. Alanine is synthesized in a single transamination step from which alpha-keto acid?
(A) Oxaloacetate
(B) Alpha-ketoglutarate
(C) Pyruvate
(D) Alpha-ketoisocaproate

2015

136. Aspartate is generated via the transamination of which TCA cycle intermediate?
(A) Citrate
(B) Succinyl-CoA
(C) Alpha-ketoglutarate
(D) Oxaloacetate

2014

137. Which non-essential amino acid is synthesized directly by the amidation of aspartate?
(A) Asparagine
(B) Glutamine
(C) Proline
(D) Arginine

2016

138. Proline is synthesized through a pathway that originates from which amino acid?
(A) Serine
(B) Glutamate
(C) Glycine
(D) Histidine

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(B) Liver failure preventing the synthesis of sufficient glycogen reserves
(C) Dietary lipids consumed in quantities exceeding mitochondrial capacity
(D) Insulin deficiency and glucagon excess driving lipolysis and ketogenesis

2005

185. In untreated Type 1 Diabetes Mellitus, why does hypertriglyceridemia often occur?
(A) Decreased activity of lipoprotein lipase (LPL) due to lack of insulin
(B) Enhanced hepatic lipogenesis
(C) Increased absorption of dietary fats
(D) Overactivity of adipose triglyceride lipase (ATGL)

2001

186. Fatty liver syndrome (hepatic steatosis) in high-yielding dairy cattle is pathologically characterized by:
(A) The lack of dietary carbohydrates causing structural lipid breakdown
(B) Inability to synthesize VLDL fast enough to export hepatic lipid influx
(C) A viral infection of the hepatocytes
(D) Overconsumption of ruminally protected fats

2015

187. Familial hypercholesterolemia is most commonly caused by mutations in the gene encoding:
(A) HMG-CoA reductase
(B) The LDL receptor
(C) Apolipoprotein B-48
(D) Lipoprotein lipase

2009

188. Which biochemical marker is characteristically elevated in the blood during diabetic ketoacidosis besides glucose and ketone bodies?
(A) Potassium (initially)
(B) Bicarbonate
(C) Calcium
(D) Insulin

2019

189. A defect in the muscle isoform of glycogen phosphorylase leads to which condition?
(A) Cori's disease
(B) Andersen's disease
(C) McArdle's disease
(D) Tarui's disease

2008

190. Consider the following assertion and reason regarding the respirations observed in diabetic ketoacidosis:
Assertion (A): In diabetic ketoacidosis, patients exhibit deep, rapid breathing known as Kussmaul respirations.
Reason (R): The respiratory system attempts to compensate for metabolic acidosis by blowing off excess CO_2.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

191. Hyperammonemia can lead to severe neurotoxicity. What is the proposed primary biochemical mechanism for this central nervous system damage?
(A) Depletion of brain ATP due to overactivation of glycolysis
(B) Direct inhibition of the electron transport chain by ammonia
(C) Depletion of alpha-ketoglutarate via synthesis of glutamate and glutamine
(D) Precipitation of urea crystals in the cerebral cortex

2008

192. A congenital deficiency in Ornithine Transcarbamylase (OTC) leads to hyperammonemia and increased urinary excretion of:
(A) Uric acid
(B) Orotic acid
(C) Citrulline
(D) Arginine

2004

193. The underlying biochemical cause of Gout is:
(A) Overproduction of urea leading to crystal formation in joints
(B) A deficiency in the purine salvage pathway enzyme APRT
(C) Impaired pyrimidine degradation
(D) Excessive production or reduced renal excretion of insoluble urate crystals

2016

194. Lesch-Nyhan syndrome is a severe X-linked recessive disorder characterized by hyperuricemia and self-mutilation. It is caused by a complete deficiency of:

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I. It is catalyzed by Nitric Oxide Synthase (NOS).
II. The substrate is the amino acid arginine.
III. Citrulline is formed as a byproduct.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I and II
(C) II and III
(D) I and III

2005

151. Creatine is synthesized from three amino acids. Which of the following sets is correct?
(A) Serine, Glycine, Glutamate
(B) Arginine, Lysine, Methionine
(C) Glycine, Arginine, Methionine
(D) Glutamine, Aspartate, Glycine

2006

152. Melatonin, a hormone regulating circadian rhythms, is synthesized in the pineal gland directly from:
(A) Epinephrine
(B) Dopamine
(C) Histamine
(D) Serotonin

2016

153. Thyroid hormones (T_3 and T_4) are biologically active derivatives synthesized from the lodination of:
(A) Tyrosine residues within the protein thyroglobulin
(B) Free circulating tyrosine
(C) Free circulating tryptophan
(D) Tryptophan residues within albumin

2025

154. The synthesis of the coenzyme Nicotinamide Adenine Dinucleotide (NAD+) can occur de novo utilizing which amino acid as a precursor?
(A) Tyrosine
(B) Tryptophan
(C) Histidine
(D) Glutamate

2018

155. Select the correct order of intermediates in the synthesis of epinephrine:
(A) Tyrosine → Dopamine → DOPA → Norepinephrine → Epinephrine
(B) Tyrosine → DOPA → Dopamine → Norepinephrine → Epinephrine
(C) Tyrosine → Norepinephrine → Dopamine → DOPA → Epinephrine
(D) Tyrosine → DOPA → Norepinephrine → Dopamine → Epinephrine

2014

156. The committed step in the de novo biosynthesis of purine nucleotides is the formation of 5-phosphoribosyl-1-amine. Which molecule serves as the nitrogen donor?
(A) Glutamine
(B) Aspartate
(C) Glycine
(D) Free ammonia

2005

157. PRPP (5-Phosphoribosyl-1-pyrophosphate) is an essential substrate in nucleotide metabolism. From which carbohydrate is it directly derived?
(A) Glucose-6-phosphate
(B) Fructose-1,6-bisphosphate
(C) Ribose-5-phosphate
(D) Xylulose-5-phosphate

2011

158. The entire glycine molecule is incorporated into the growing purine ring. Which atoms of the purine ring does glycine provide?
(A) N_1, C_2, and N_3
(B) C_6 and N_1
(C) C_2 and C_8
(D) C_4, C_5, and N_7

2013

159. What is the first fully formed purine nucleotide in the de novo synthesis pathway?
(A) AMP
(B) GMP
(C) IMP (Inosine monophosphate)
(D) XMP

2022

160. Consider the following statements about pyrimidine biosynthesis:
I. The pyrimidine ring is assembled before attachment to PRPP.
II. Carbamoyl phosphate synthetase II (CPS II) is the regulatory enzyme.
III. CPS II is located in the cytosol.
IV. UMP is formed by the decarboxylation of Orotidylate (OMP).
Which of the above statement(s) is/are correct?
(A) I and II only
(B) II and III only
(C) I, II and III only
(D) I, II, III and IV

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2018

161. In the de novo synthesis of pyrimidines, the nitrogen and carbon atoms of the ring are derived solely from:
(A) Glutamine, Glycine, and CO_2
(B) Aspartate, Glycine, and Formate
(C) Glutamate, Ammonia, and CO_2
(D) Glutamine, Aspartate, and CO_2

2009

162. Ribonucleotide reductase catalyzes the conversion of ribonucleotides to deoxyribonucleotides. It requires a specific small protein as an electron donor called:
(A) Thioredoxin
(B) Cytochrome c
(C) Ferredoxin
(D) Plastocyanin

2004

163. The biosynthesis of dTMP from dUMP requires the enzyme thymidylate synthase and which crucial coenzyme?
(A) S-adenosylmethionine (SAM)
(B) Pyridoxal phosphate
(C) N5,$N_1$0-methylene-tetrahydrofolate
(D) Biotin

2004

164. The salvage pathway for purines requires the enzyme HGPRT (Hypoxanthine-guanine phosphoribosyltransferase). It catalyzes the conversion of:
(A) Hypoxanthine to IMP and Guanine to GMP
(B) Adenine to AMP
(C) Guanine to AMP
(D) Hypoxanthine to Uric Acid

2015

165. The final end product of purine catabolism in humans and higher primates is:
(A) Urea
(B) Allantoin
(C) Ammonia
(D) Uric acid

2002

166. In most non-primate mammals, uric acid is further degraded to a more water-soluble compound by the enzyme urate oxidase. What is this compound?
(A) Xanthine
(B) Allantoin
(C) Urea
(D) Creatinine

2003

167. Which enzyme catalyzes the oxidation of hypoxanthine to xanthine, and xanthine to uric acid?
(A) Adenosine deaminase
(B) Uricase
(C) Xanthine oxidase
(D) HGPRT

2022

168. Allopurinol is a structural analog of hypoxanthine and acts as a potent inhibitor of:
(A) Adenine phosphoribosyltransferase
(B) Ribonucleotide reductase
(C) Thymidylate synthase
(D) Xanthine oxidase

2014

169. Glucose-6-phosphate represents a major metabolic junction. Which of the following is NOT a direct metabolic fate of Glucose-6-phosphate?
(A) Direct conversion to Acetyl-CoA
(B) Entry into glycolysis via isomerization to Fructose-6-phosphate
(C) Conversion to Glucose-1-phosphate for glycogenesis
(D) Entry into the pentose phosphate pathway via oxidation

2013

170. Consider the following metabolic roles of Pyruvate:
I. Reduction to Lactate in anaerobic glycolysis
II. Transamination to Alanine
III. Carboxylation to Oxaloacetate
IV. Oxidative decarboxylation to Acetyl-CoA
V. Direct conversion to Acetoacetate
Which of the above statement(s) is/are correct?
(A) I, II, III, IV
(B) I, III, IV, V
(C) II, III, IV, V
(D) I, II, IV, V

2024

171. Acetyl-CoA is a critical metabolic hub. It can be used for the synthesis of all the following EXCEPT:
(A) Fatty acids
(B) Glucose
(C) Cholesterol
(D) Ketone bodies

2015

172. During the early fasting state, which process is the primary source of blood glucose maintenance?

NODIA

(A) Hepatic glycogenolysis
(B) Hepatic gluconeogenesis from muscle amino acids
(C) Renal gluconeogenesis
(D) Muscle glycogenolysis

2025

173. As starvation progresses into prolonged fasting (days to weeks), the brain adapts to utilize which alternative fuel source?
(A) Free fatty acids
(B) Glycerol
(C) Ketone bodies
(D) Lactate

2007

174. Which organ assumes a significant role in gluconeogenesis during prolonged starvation, nearly matching the liver's output?
(A) Skeletal muscle
(B) Adipose tissue
(C) Small intestine
(D) Kidneys (renal cortex)

2025

175. The dominant hormone driving the metabolic adaptations in the well-fed state is:
(A) Glucagon
(B) Epinephrine
(C) Insulin
(D) Cortisol

2005

176. Which of the following best characterizes the metabolic profile of resting skeletal muscle in a fasting individual?
(A) High rate of glucose uptake
(B) Reliance on fatty acids as the primary energy source
(C) High rate of de novo lipogenesis
(D) Export of ketone bodies to the brain

2023

177. Adipose tissue lacks the enzyme glycerol kinase. How does it obtain glycerol-3-phosphate for triacylglycerol synthesis?
(A) It absorbs intact triacylglycerol from the blood
(B) It synthesizes it directly from free glycerol via an alternative kinase
(C) It imports it from the liver
(D) It synthesizes it from dihydroxyacetone phosphate (DHAP) produced during glycolysis

2021

178. Erythrocytes rely exclusively on glycolysis for ATP production because they lack:
(A) Mitochondria
(B) A nucleus
(C) Hexokinase
(D) Glucose transporters

2024

179. The Cori cycle facilitates the exchange of metabolites between muscle and liver. Which two compounds are primarily exchanged?
(A) Glucose and Alanine
(B) Lactate and Pyruvate
(C) Glucose and Lactate
(D) Alanine and Glutamine

2023

180. During intense physical exertion, the accumulation of which molecule strongly allosterically activates muscle glycogen phosphorylase?
(A) AMP
(B) ATP
(C) Glucose-6-phosphate
(D) NADH

2021

181. Von Gierke's disease (Glycogen Storage Disease Type I) is fundamentally caused by a genetic deficiency in:
(A) Glycogen phosphorylase
(B) Debranching enzyme
(C) Lysosomal alpha-1,4-glucosidase
(D) Glucose-6-phosphatase

2006

182. Which of the following clinical signs is NOT typically associated with Von Gierke's disease?
(A) Severe fasting hypoglycemia
(B) Muscle weakness and cramping during exercise
(C) Hepatomegaly
(D) Hyperuricemia

2013

183. Pompe disease (Glycogen Storage Disease Type II) uniquely affects which cellular organelle?
(A) Mitochondria
(B) Endoplasmic reticulum
(C) Lysosomes
(D) Peroxisomes

2004

184. The fundamental biochemical mechanism driving diabetic ketoacidosis (DKA) is:
(A) Excessive insulin levels driving accelerated glucose storage in adipocytes

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(B) Sulfur-containing amino acids
(C) Branched-chain amino acids
(D) Basic amino acids

2009

205. The primary biochemical marker accumulating in the blood and urine of a patient with Maple Syrup Urine Disease is/are:
(A) Homogentisic acid
(B) Phenylpyruvate and phenyllactate
(C) Methylmalonic acid
(D) Alpha-keto acids derived from leucine, isoleucine, and valine

2021

206. A variant form of PKU can occur despite a normal phenylalanine hydroxylase gene. This is typically due to a deficiency in the biosynthesis or recycling of:
(A) Pyridoxal phosphate (PLP)
(B) Tetrahydrofolate (THF)
(C) Tetrahydrobiopterin (BH4)
(D) S-adenosylmethionine (SAM)

2018

207. Which of the following is the most direct consequence of untreated Alkaptonuria in adulthood?
(A) Profound intellectual disability
(B) Ochronosis and severe early-onset arthritis
(C) Hypopigmentation of skin and hair
(D) Liver failure

2019

208. The standard dietary management for a newborn diagnosed with classical PKU is:
(A) Complete elimination of all dietary protein
(B) A diet enriched in branched-chain amino acids
(C) High doses of Vitamin B_{12} and folate
(D) A diet severely restricted in phenylalanine but supplemented with tyrosine

2019

209. Somatic gene therapy fundamentally involves:
(A) Introducing functional genetic material into targeted non-reproductive cells of an individual
(B) Modifying the DNA in sperm or egg cells so the changes are heritable
(C) Administering recombinant proteins to replace missing enzymes
(D) Using drugs to alter mRNA translation rates

NODIA

2019

210. Select the correct sequence of steps involved in a standard ex vivo somatic gene therapy procedure:
(A) Cell isolation → Transduction with vector → Culture and expansion → Reinfusion into patient
(B) Transduction with vector → Cell isolation → Reinfusion → Culture and expansion
(C) Culture and expansion → Reinfusion → Cell isolation → Transduction
(D) Transduction in vivo → Biopsy → Culture → Reinfusion

2023

211. Which of the following viral vectors integrates directly into the host cell's genome, providing stable, long-term expression but carrying a risk of insertional mutagenesis?
(A) Retrovirus
(B) Adenovirus
(C) Adeno-associated virus (AAV)
(D) Herpes simplex virus

2024

212. Adeno-associated viruses (AAVs) are highly preferred vectors in modern gene therapy because:
(A) They have an enormous packaging capacity (up to 30 kb)
(B) They exclusively infect dividing cells
(C) They possess highly error-prone reverse transcriptase
(D) They evoke minimal immune responses and typically remain episomal

2001

213. Non-viral gene delivery systems, such as lipid nanoparticles (LNPs), offer which major advantage over viral vectors?
(A) Much higher transfection efficiency in vivo
(B) Lower immunogenicity and capacity to package larger nucleic acid constructs
(C) The ability to permanently integrate into specific genomic loci
(D) Self-replication within the host cell

2013

214. The CRISPR-Cas9 system has revolutionized targeted gene editing. What is the specific function of the Cas9 protein?
(A) It synthesizes new DNA to repair a mutation
(B) It transports the guide RNA into the nucleus
(C) It acts as an RNA-guided endonuclease to create targeted double-strand breaks
(D) It ligates the broken DNA ends together

(A) Hypoxanthine-guanine phosphoribosyltransferase (HGPRT)
(B) Adenosine deaminase (ADA)
(C) Xanthine oxidase
(D) PRPP synthetase

2008

195. Why does a deficiency in HGPRT lead to massive overproduction of uric acid?
(A) It directly activates xanthine oxidase
(B) It prevents the kidney from excreting uric acid
(C) Increased PRPP levels driving purine synthesis coupled with salvage loss
(D) It causes an overproduction of pyrimidines which are converted to uric acid

2017

196. Severe Combined Immunodeficiency (SCID) is often caused by a genetic defect in which enzyme of purine metabolism?
(A) Adenosine deaminase (ADA)
(B) Purine nucleoside phosphorylase (PNP)
(C) Ribonucleotide reductase
(D) Hypoxanthine-guanine phosphoribosyltransferase (HGPRT)

2011

197. The pathogenesis of ADA deficiency involves the accumulation of deoxyadenosine. This metabolite is toxic because it:
(A) Forms insoluble crystals in T-cells
(B) Directly destroys the nuclear membrane
(C) Acts as a false neurotransmitter
(D) Conversion to dATP which inhibits ribonucleotide reductase and DNA synthesis

2013

198. Which of the following treatments is the definitive cure for Lesch-Nyhan syndrome?
(A) Administration of Allopurinol
(B) There is currently no cure for the neurological symptoms
(C) Dietary restriction of purines
(D) Enzyme replacement therapy

2024

199. Classical Phenylketonuria (PKU) is caused by a mutation in the gene encoding:
(A) Tyrosine aminotransferase
(B) Homogentisate oxidase
(C) Phenylalanine hydroxylase
(D) Branched-chain keto acid dehydrogenase

2004

200. Consider the following match of inborn errors of metabolism and their corresponding deficient enzymes:
List I: (Inborn Errors of Metabolism)
P. Alkaptonuria
Q. Maple Syrup Urine Disease
R. Albinism
S. Phenylketonuria
List II: (Deficient Enzymes)
1. Tyrosinase
2. Phenylalanine hydroxylase
3. Homogentisate 1,2-dioxygenase
4. Branched-chain alpha-keto acid dehydrogenase
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-1, R-4, S-2

2012

201. If untreated, classical PKU results in severe intellectual disability. Which biochemical mechanism primarily accounts for this?
(A) Tyrosine toxicity destroys neurons
(B) Accumulated phenylalanine inhibiting transport of large neutral amino acids
(C) Excessive synthesis of dopamine causes excitotoxicity
(D) Phenylpyruvate acts as a strong competitive inhibitor of the electron transport chain

2006

202. The presence of dark, melanin-like pigments in the urine upon standing is the pathognomonic sign of:
(A) Phenylketonuria
(B) Alkaptonuria
(C) Maple Syrup Urine Disease
(D) Homocystinuria

2018

203. Albinism is a group of genetic conditions characterized by a lack of melanin pigment. Oculocutaneous albinism type 1 is specifically caused by a defect in:
(A) Tyrosinase
(B) Phenylalanine hydroxylase
(C) DOPA decarboxylase
(D) Melanin transport proteins

2024

204. Maple Syrup Urine Disease (MSUD) affects the catabolism of which specific group of amino acids?
(A) Aromatic amino acids

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2024

226. When ΔG of a reaction is zero, the system is:
(A) Proceeding forward at a maximum rate
(B) Exergonic
(C) At equilibrium
(D) Endergonic

2024

227. Coupling of endergonic reactions to ATP hydrolysis fundamentally relies on:
(A) The formation of a common intermediate
(B) The physical proximity of the enzymes
(C) The dissipation of heat
(D) The reduction of oxygen

2017

228. The standard redox potential (E°) measures:
(A) The rate of electron transfer
(B) The number of protons pumped
(C) The total energy of the chemical bond
(D) The affinity of a molecule for electrons

2011

229. A positive ΔE° corresponds to a:
(A) Positive ΔG°, indicating a non-spontaneous reaction
(B) Negative ΔG°, indicating a spontaneous reaction
(C) Reaction at equilibrium
(D) Highly endergonic process

2005

230. Arrange the following electron carriers in order of their increasing standard reduction potential (from most negative to most positive):
I. NAD+
II. Cytochrome c
III. FAD
IV. Oxygen (O_2)
(A) I, III, II, IV
(B) I, II, III, IV
(C) III, I, II, IV
(D) IV, II, III, I

2002

231. The transfer of a phosphate group from ATP to glucose is an example of:
(A) Oxidative phosphorylation
(B) Substrate-level phosphorylation
(C) Hydrolytic cleavage
(D) Group transfer potential

2009

232. Which of the following statements about the ATP-ADP cycle is most accurate?
(A) ATP acts as an intermediate carrier of phosphoryl groups linking catabolism and anabolism
(B) ADP acts as a universal methyl donor
(C) The cycle is driven strictly by temperature changes
(D) AMP is the primary energy currency

2015

233. The high-energy nature of thioesters is due to:
(A) Strong resonance stabilization of the ester bond
(B) The large atomic radius of sulfur preventing orbital overlap and resonance stabilization
(C) The highly oxidized state of the sulfur atom
(D) The strong hydrogen bonds formed by sulfur

2016

234. In the absence of oxygen, how does the electron transport chain respond?
(A) It switches to utilizing nitrogen as an electron acceptor
(B) All carriers accumulate in their reduced state, halting electron flow
(C) All carriers accumulate in their oxidized state
(D) It reverses direction to synthesize NADH

2002

235. The iron-sulfur clusters in the electron transport chain undergo redox cycling between which two oxidation states?
(A) $Fe^{\{2+\}}$ and $Fe^{\{3+\}}$
(B) $Fe^{\{0\}}$ and $Fe^{\{2+\}}$
(C) $Fe^{\{3+\}}$ and $Fe^{\{4+\}}$
(D) $Fe^{\{1+\}}$ and $Fe^{\{2+\}}$

NODIA

2002

236. Cytochrome c oxidase (Complex IV) uniquely contains which metal center essential for transferring electrons to oxygen?
(A) Zinc
(B) Magnesium
(C) Copper
(D) Manganese

2024

237. The number of protons pumped across the inner mitochondrial membrane per pair of electrons transferred from NADH to Oxygen is generally accepted to be:
(A) 4
(B) 6
(C) 10
(D) 12

2021

215. In CRISPR-based interventions, what dictates the exact genomic sequence that Cas9 will cleave?
(A) The specific protein domains within Cas9
(B) The presence of a homologous repair template
(C) The single guide RNA (sgRNA) sequence
(D) The concentration of Cas9 protein

2007

216. Which of the following pathways repairs Cas9-induced double-strand breaks and is predominantly utilized to create targeted gene knockouts via insertions or deletions (indels)?
(A) Non-homologous end joining (NHEJ)
(B) Homology-directed repair (HDR)
(C) Base excision repair (BER)
(D) Mismatch repair (MMR)

2003

217. If the goal of a CRISPR intervention is to perfectly correct a pathogenic point mutation, which repair mechanism must be forced to occur in the presence of a donor DNA template?
(A) NHEJ
(B) Homology-directed repair (HDR)
(C) Nucleotide excision repair
(D) SOS response

2007

218. A major challenge in in vivo CRISPR-Cas9 delivery is the requirement of the Cas9 enzyme to locate a specific sequence motif adjacent to the target site. What is this motif called?
(A) TATA box
(B) Protospacer Adjacent Motif (PAM)
(C) Kozak sequence
(D) Shine-Dalgarno sequence

2025

219. Luxturna was the first FDA-approved in vivo gene therapy. It utilizes an AAV vector to treat an inherited form of:
(A) Retinal dystrophy causing blindness
(B) Severe Combined Immunodeficiency (SCID)
(C) Hemophilia B
(D) Spinal muscular atrophy

2013

220. Consider the following assertion and reason regarding the suitability of retroviral vectors:
Assertion (A): Retroviral vectors are generally not suitable for delivering genes to non-dividing cells like mature neurons.
Reason (R): Retroviruses require the breakdown of the nuclear envelope during mitosis to access the host genome.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022

221. Lentiviral vectors are a subclass of retroviruses that possess a distinct advantage for gene therapy. What is it?
(A) They do not integrate into the host genome
(B) They are entirely synthetic and lack any viral proteins
(C) They cannot cause any immune response
(D) They can infect and integrate into both dividing and non-dividing cells

2024

222. An ideal delivery vector for a metabolic disorder originating in the liver must possess:
(A) Inability to escape the endosome
(B) A very short half-life in target cells
(C) High hepatotropism
(D) A tendency to activate CD8+ T-cells

2015

223. What is the fundamental difference between standard CRISPR-Cas9 and "Base Editing" technologies?
(A) Base editors only target RNA
(B) Inactive Cas9-deaminase fusions that alter bases without double-strand breaks
(C) Base editors do not require a guide RNA
(D) Base editors physically remove large segments of chromosomes

2023

224. Which condition has been a primary target for ex vivo lentiviral hematopoietic stem cell gene therapy due to ADA enzyme deficiency?
(A) Cystic Fibrosis
(B) Duchenne Muscular Dystrophy
(C) Phenylketonuria
(D) SCID (Severe Combined Immunodeficiency)

2013

225. Free energy changes in metabolic reactions depend on:
(A) The absolute temperature and the concentrations of reactants and products
(B) Only the presence of specific enzymes
(C) The speed at which the reaction occurs
(D) The size of the cell

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2018

139. Glycine can be synthesized directly from serine via the action of serine hydroxymethyltransferase. This reaction requires which vitamin-derived coenzyme?
(A) Biotin
(B) Tetrahydrofolate
(C) Cobalamin
(D) Thiamine pyrophosphate

2012

140. Consider the following match of amino acids and their corresponding carbon skeleton precursors:
List I: (Amino Acids)
P. Alanine
Q. Glutamate
R. Serine
S. Aspartate
List II: (Carbon Skeleton Precursors)
1. Alpha-ketoglutarate
2. Pyruvate
3. Oxaloacetate
4. 3-Phosphoglycerate
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-4, S-2

2013

141. Tyrosine is considered a non-essential amino acid only if the diet contains adequate amounts of:
(A) Tryptophan
(B) Methionine
(C) Phenylalanine
(D) Cysteine

2010

142. The synthesis of cysteine requires the carbon skeleton from serine and the sulfur atom from which essential amino acid?
(A) Threonine
(B) Valine
(C) Histidine
(D) Methionine

2007

143. Which of the following amino acids is both strictly ketogenic and essential?
(A) Isoleucine
(B) Valine
(C) Leucine
(D) Phenylalanine

2003

144. Catecholamines (dopamine, norepinephrine, epinephrine) are sequentially synthesized starting from which amino acid?
(A) Tryptophan
(B) Tyrosine
(C) Histidine
(D) Glutamate

2013

145. The conversion of tyrosine to DOPA, the rate-limiting step in catecholamine synthesis, is catalyzed by:
(A) DOPA decarboxylase
(B) Dopamine beta-hydroxylase
(C) Phenylethanolamine N-methyltransferase
(D) Tyrosine hydroxylase

NODIA

2008

146. Serotonin (5-hydroxytryptamine) is a key neurotransmitter derived from which amino acid?
(A) Tryptophan
(B) Tyrosine
(C) Glutamate
(D) Glycine

2007

147. Histamine, a mediator of allergic responses, is produced via the direct decarboxylation of histidine. This reaction requires:
(A) NAD+
(B) Biotin
(C) Pyridoxal phosphate (PLP)
(D) Vitamin C

2003

148. Gamma-aminobutyric acid (GABA), a major inhibitory neurotransmitter, is synthesized by the decarboxylation of:
(A) Glutamate
(B) Glutamine
(C) Aspartate
(D) Arginine

2025

149. The biosynthesis of porphyrins (e.g., heme) begins with the condensation of succinyl-CoA and which amino acid?
(A) Alanine
(B) Serine
(C) Glutamate
(D) Glycine

2023

150. Consider the following statements regarding Nitric Oxide (NO) synthesis:

2016

238. If the F_1 subunit of ATP synthase is physically detached from the Fo subunit, it will:
(A) Retain the ability to synthesize ATP
(B) Revert to an electron carrier
(C) Function as an ATP hydrolase (ATPase)
(D) Act as an uncoupling protein

2007

239. The Fo portion of the ATP synthase is sensitive to which antibiotic?
(A) Penicillin
(B) Oligomycin
(C) Streptomycin
(D) Tetracycline

2024

240. The structural organization of Fo-F_1 ATP synthase relies heavily on a rotating mechanism. Which subunit forms the static "stator" holding the alpha-beta hexamer in place?
(A) The c-ring
(B) The gamma subunit
(C) The epsilon subunit
(D) The b2-delta peripheral stalk complex

2010

241. P/O ratios reflect the coupling of oxidation to phosphorylation. Why is the P/O ratio for succinate oxidation (≈ 1.5) lower than that for NADH oxidation (≈ 2.5)?
(A) Succinate oxidation bypasses the proton-pumping Complex I
(B) Succinate dehydrogenase is an inefficient enzyme
(C) FADH2 directly reduces oxygen
(D) Complex II hydrolyzes ATP

2015

242. Chemical uncouplers of oxidative phosphorylation, such as DNP, are characterized structurally as:
(A) Hydrophilic bases
(B) Charged metal ions
(C) Lipophilic weak acids
(D) Large polar polypeptides

2016

243. In glycolysis, what is the energetic logic of phosphorylating glucose in the first step?
(A) It traps glucose inside the cell and destabilizes it for further cleavage
(B) It provides direct ATP synthesis
(C) It makes the molecule highly lipid-soluble
(D) It immediately yields NADH

NODIA

2023

244. The enzymatic step in glycolysis that constitutes a C-C bond cleavage is catalyzed by:
(A) Triose phosphate isomerase
(B) Enolase
(C) Phosphoglycerate mutase
(D) Aldolase

2019

245. Under aerobic conditions, the NADH produced in glycolysis is regenerated to NAD+ primarily via:
(A) The conversion of pyruvate to lactate
(B) Transport of reducing equivalents into the mitochondria via shuttles for the ETC
(C) The conversion of pyruvate to ethanol
(D) The oxidative phase of the PPP

2004

246. Consider the following statements about Fructose-2,6-bisphosphate (F-2,6-BP):
I. It is an intermediate in the glycolytic pathway.
II. It is a potent allosteric activator of PFK-1.
III. It inhibits Fructose-1,6-bisphosphatase.
IV. Its levels rise in the liver in response to insulin.
Which of the above statement(s) is/are correct?
(A) II, III and IV
(B) I, II and III
(C) I, III and IV
(D) I, II, III and IV

2016

247. The conversion of 3-phosphoglycerate to 2-phosphoglycerate is essentially the transfer of a phosphoryl group. Which enzyme catalyzes this?
(A) Phosphoglycerate kinase
(B) Enolase
(C) Aldolase
(D) Phosphoglycerate mutase

2012

248. The biochemical basis of Von Gierke's disease involves failure to convert:
(A) Glucose-6-phosphate to free Glucose
(B) Glycogen to Glucose-1-phosphate
(C) Pyruvate to Acetyl-CoA
(D) Fructose to Fructose-1-phosphate

2003

249. Coenzyme A (CoA) is a universal carrier of acyl groups. The reactive site of CoA is a:
(A) Hydroxyl group
(B) Terminal sulfhydryl (-SH) group
(C) Phosphate group

(D) Propensity to elicit robust and potentially fatal systemic immune responses

2010

293. The delivery of CRISPR-Cas9 components via Lipid Nanoparticles (LNPs) generally involves encapsulating:
(A) Cas9 protein directly
(B) Cas9 mRNA and the guide RNA
(C) Live viral particles
(D) Naked genomic DNA

2003

294. Somatic gene transfer is distinguished from germline gene transfer fundamentally because:
(A) Somatic transfer uses viral vectors while germline uses non-viral vectors
(B) Somatic transfer exclusively targets the epidermal and dermal skin layers
(C) Modification of non-reproductive cells without affecting future generations
(D) Somatic transfer is currently strictly prohibited by international law

2007

295. Which in vivo gene therapy vector has been successfully utilized to treat Spinal Muscular Atrophy by crossing the blood-brain barrier and targeting motor neurons?
(A) Lentivirus
(B) Adenovirus
(C) Retrovirus
(D) AAV9

2005

296. When HDR (Homology-Directed Repair) is used in CRISPR-based gene editing, the cell utilizes the provided donor template during which phase of the cell cycle?
(A) Early S to G_2 phase
(B) G_1 phase
(C) M phase
(D) G0 phase

2023

297. Off-target effects in CRISPR-Cas9 gene editing refer to:
(A) The Cas9 enzyme degrading RNA instead of DNA
(B) The unintended cleavage of DNA sequences that are partially complementary to the sgRNA
(C) The immune system destroying the Cas9 protein
(D) The failure of the sgRNA to bind to the PAM sequence

2006

298. Consider the following challenges in utilizing non-viral delivery vectors (e.g., liposomes) for gene therapy:
I. Transient expression of the transgene.
II. Lower transduction efficiency compared to viral vectors.
III. Potential for insertional mutagenesis.
IV. Endosomal entrapment and degradation.
V. High immunogenicity preventing repeated administration.
Which of the above statement(s) is/are correct?
(A) I, II, IV
(B) II, III, V
(C) I, III, IV
(D) III, IV, V

2013

299. The "Prime Editing" system is an advancement over standard CRISPR-Cas9 because it:
(A) Writes new genetic information without requiring double-strand breaks
(B) Utilizes an un-tethered, wildly active nuclease
(C) Only targets mitochondrial DNA
(D) Functions exclusively in prokaryotes

2022

300. In designing a gene therapy protocol for Hemophilia A (Factor VIII deficiency), why might lentiviral vectors be preferred for ex vivo hematopoietic stem cell modification over AAV?
(A) Lentiviruses do not integrate into the genome
(B) AAV causes massive cell lysis in stem cells
(C) Large Factor VIII gene size exceeds the packaging capacity of AAV vectors
(D) Lentiviral vectors are entirely non-immunogenic

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2019

260. Consider the following match of disease conditions and their metabolic characteristics:
List I: (Disease Conditions)
P. Diabetic Ketoacidosis
Q. Fatty Liver Syndrome
R. Familial Hypercholesterolemia
S. Gout
List II: (Metabolic Characteristics)
1. Excess NEFA influx exceeding hepatic VLDL export
2. Defective LDL receptor function
3. Unrestrained lipolysis and ketone overproduction
4. Monosodium urate crystal deposition
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-1, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-4, R-1, S-3

2011

261. Pyridoxal phosphate (PLP) is essential for glycogenolysis because it acts as a cofactor for:
(A) Glycogen synthase
(B) Glycogen phosphorylase
(C) Debranching enzyme
(D) Phosphoglucomutase

2018

262. In the beta-oxidation of odd-chain fatty acids, the propionyl-CoA generated is eventually converted to succinyl-CoA. This pathway requires which two vitamins?
(A) Thiamine and Riboflavin
(B) Folate and Vitamin B_6
(C) Biotin and Vitamin B_{12}
(D) Niacin and Pantothenic acid

2014

263. The primary site of short-chain fatty acid absorption and direct entry into portal circulation in ruminants is the:
(A) Abomasum
(B) Small intestine
(C) Large intestine
(D) Rumen epithelium

2023

264. Malonyl-CoA, an intermediate in fatty acid synthesis, strictly inhibits which transport system to prevent futile cycling?
(A) Carnitine palmitoyltransferase I (CPT-I)
(B) Citrate transporter
(C) Glucose transporter 4 ($GLUT_4$)
(D) Adenine nucleotide translocase

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2001

265. The Fatty Acid Synthase (FAS) complex in mammals is structurally best described as a:
(A) Multifunctional monomer
(B) Homodimer with multiple enzymatic domains on one polypeptide chain
(C) Complex of seven independent, separable proteins
(D) Tetramer located in the mitochondrial matrix

2022

266. Desaturation of fatty acids in mammalian cells occurs primarily in the:
(A) Cytosol
(B) Endoplasmic reticulum
(C) Mitochondrial matrix
(D) Golgi apparatus

2025

267. Ruminants synthesize the vast majority of their glucose via gluconeogenesis primarily utilizing:
(A) Propionate
(B) Dietary glucose
(C) Acetate
(D) Long-chain fatty acids

2004

268. Why is bovine ketosis most prevalent during early lactation?
(A) High levels of blood glucose inhibit the TCA cycle
(B) The diet is typically deficient in lipids
(C) Limited oxaloacetate levels forcing excess acetyl-CoA into ketogenic pathways
(D) Mammary gland strictly utilizes ketone bodies for milk fat synthesis

2004

269. The initial statin drugs were discovered based on their structural similarity to:
(A) Cholesterol
(B) Mevalonate
(C) Squalene
(D) HMG-CoA

2010

270. Consider the following statements regarding amino acid catabolism:
I. Ammonia is highly neurotoxic.
II. Urea is synthesized in the kidneys and excreted by the liver.
III. Glutamate dehydrogenase catalyzes an oxidative deamination.
Which of the above statement(s) is/are correct?
(A) I and III

(D) Adenine ring

2019

250. Consider the following assertion and reason regarding the metabolic nature of the Citric Acid Cycle:
Assertion (A): The Citric Acid Cycle is considered an amphibolic pathway.
Reason (R): It serves in both the catabolic oxidation of carbohydrates and lipids, and provides anabolic precursors for amino acid and porphyrin synthesis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

251. The step catalyzed by Isocitrate Dehydrogenase generates:
(A) NADH and CO_2
(B) FADH2 and CO_2
(C) ATP and H_2O
(D) GTP and CoA

2025

252. Malonate is a classic competitive inhibitor of which enzyme?
(A) Fumarase
(B) Citrate synthase
(C) Succinate dehydrogenase
(D) Malate dehydrogenase

2014

253. Which intermediate of the TCA cycle is an allosteric inhibitor of PFK-1 in glycolysis?
(A) Succinate
(B) Malate
(C) Oxaloacetate
(D) Citrate

2021

254. If anaplerotic reactions do not function adequately, what is the direct metabolic consequence?
(A) Overproduction of ATP
(B) Immediate conversion of the cell to anaerobic fermentation
(C) Depletion of cycle intermediates leading to reduced acetyl-CoA oxidation
(D) Massive synthesis of glycogen

2025

255. The transaldolase reaction in the pentose phosphate pathway specifically transfers a:
(A) 1-carbon moiety
(B) 3-carbon moiety
(C) 2-carbon moiety
(D) 4-carbon moiety

2014

256. Glucose-6-phosphate dehydrogenase deficiency results in hemolytic anemia because:
(A) The red blood cells lack ATP for membrane pumps
(B) High levels of NADP+ destroy the cell membrane
(C) Ribose-5-phosphate accumulates to toxic levels
(D) Inability to produce NADPH to maintain glutathione against oxidative damage

2006

257. Which metabolic condition upregulates the activity of the pentose phosphate pathway in adipose tissue?
(A) High demand for fatty acid biosynthesis during the fed state
(B) Starvation
(C) Severe hypoxia
(D) Glucagon stimulation

2006

258. Glycogen structurally differs from starch (amylopectin) primarily by having:
(A) Beta-1,4 linkages instead of alpha-1,4 linkages
(B) Only unbranched chains
(C) Highly frequent alpha-1,6 branch points resulting in more compact structures
(D) Fructose residues incorporated into the backbone

2001

259. Consider the following statements regarding the regulation of Glycogen Synthase (GS):
I. It is inactivated by phosphorylation.
II. Insulin signaling leads to its activation.
III. GSK-3 phosphorylates and inhibits GS.
IV. Glucose-6-phosphate acts as a strong allosteric activator.
V. Glucagon promotes its dephosphorylation.
Which of the above statement(s) is/are correct?
(A) I, II, III, IV
(B) II, III, IV, V
(C) I, III, IV, V
(D) I, II, IV, V

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(A) It remains as THF
(B) It is oxidized to Dihydrofolate (DHF)
(C) It is degraded to uric acid
(D) It is converted directly to SAM

2011

283. Methotrexate acts as a potent chemotherapeutic agent by specifically inhibiting:
(A) Dihydrofolate reductase (DHFR)
(B) Xanthine oxidase
(C) Adenosine deaminase
(D) Ribonucleotide reductase

2005

284. Allopurinol acts as a suicide inhibitor of xanthine oxidase. Upon binding, it is converted to a highly tightly bound intermediate called:
(A) Hypoxanthine
(B) Uric acid
(C) Oxypurinol
(D) PRPP

2003

285. In adenosine deaminase (ADA) deficiency, the accumulation of dATP leads to the direct allosteric inhibition of which crucial enzyme?
(A) Thymidylate synthase
(B) PRPP synthetase
(C) DNA polymerase
(D) Ribonucleotide reductase

2003

286. Lesch-Nyhan syndrome patients exhibit severe self-injurious behavior. This is hypothesized to be related to the dysfunction of which neurotransmitter system linked to the purine defect?
(A) Serotonon
(B) Acetylcholine
(C) Dopamine
(D) GABA

2004

287. Which viral vector system relies on integration into the host genome but predominantly targets dividing cells, making it suitable for ex vivo stem cell therapy but poor for in vivo neuronal therapy?
(A) Lentivirus
(B) Gammaretrovirus
(C) Adenovirus
(D) Adeno-associated virus

2001

288. In the context of somatic gene therapy, an episome is defined as:
(A) A piece of DNA that inserts randomly into the host chromosome
(B) A viral capsid protein that triggers an immune response
(C) A guide RNA used in CRISPR
(D) An extrachromosomal circular DNA molecule that replicates independently or persists without integrating

2014

289. The CRISPR-Cas system naturally evolved in bacteria and archaea primarily as a mechanism for:
(A) Adaptive immunity against bacteriophages and plasmids
(B) Metabolic regulation
(C) DNA repair during extreme heat stress
(D) Quorum sensing

NODIA

2011

290. Consider the following components relevant to CRISPR-Cas9 targeted interventions:
I. Cas9 Endonuclease
II. sgRNA (Single guide RNA)
III. Protospacer Adjacent Motif (PAM)
IV. Donor DNA template for HDR
V. Viral delivery vector
Which combination of components is strictly essential for creating a targeted genetic knockout via NHEJ without inserting new sequence?
(A) I, II, III
(B) I, II, III, IV, V
(C) I, III, IV
(D) II, III, IV, V

2002

291. For treating a metabolic disorder like PKU via in vivo liver-directed gene therapy, which vector provides the best balance of safety, high hepatocyte transduction, and long-term episomal expression?
(A) AAV (Adeno-associated virus)
(B) Gammaretrovirus
(C) Herpes Simplex Virus
(D) Naked plasmid DNA

2002

292. A significant limitation of using Adenovirus as a gene therapy vector is:
(A) Its very small packaging capacity for genetic inserts
(B) Its inability to transduce non-dividing cellular targets
(C) Its strict requirement to integrate into the host genome

step of the electron transport chain. As a result, cellular respiration ceases, the proton gradient dissipates, and ATP production is halted.

28. (C) FMN
In the mitochondrial respiratory chain, complex I receives electrons from NADH. Flavin mononucleotide serves as the initial electron acceptor within this large protein assembly. FMN is a two-electron carrier that accepts a hydride ion from NADH and subsequently passes individual electrons to a series of iron-sulfur clusters, which then transfer them to the mobile carrier ubiquinone for further transport.

29. (D) Four protons are translocated for every two electrons moved
The Q-cycle is a mechanism that operates within complex III of the electron transport chain. Its primary metabolic consequence is the translocation of four protons from the mitochondrial matrix into the intermembrane space for every pair of electrons that pass through the complex. This efficient process significantly enhances the proton motive force used by ATP synthase for energy production.

30. (C) I and III
Mitchell's chemiosmotic hypothesis states that an intact inner mitochondrial membrane is essential to maintain a proton gradient. The electrochemical gradient, which drives ATP synthesis, consists of both a pH difference and an electrical potential. Statement II is incorrect because electron transport does not directly phosphorylate ADP; rather, it creates the gradient that then powers the phosphorylation via ATP synthase.

31. (B) Both a pH gradient and a transmembrane electrical potential
The proton motive force is the stored energy resulting from the unequal distribution of protons across the inner mitochondrial membrane. It is composed of two distinct thermodynamic components: a chemical gradient, representing the difference in pH, and an electrical gradient, representing the separation of charge. Together, these two forces drive protons back into the matrix through the ATP synthase.

32. (D) It acts as a transmembrane proton channel into the matrix
The Fo portion of the ATP synthase is a hydrophobic complex embedded within the inner mitochondrial membrane. Its primary function is to serve as a specialized channel that allows protons to flow down their electrochemical gradient from the intermembrane space into the matrix. This flow of protons triggers the rotation of the c-ring, which is essential for synthesis.

33. (A) Beta subunit
The F_1 portion of the ATP synthase complex is a peripheral membrane protein assembly that projects into the mitochondrial matrix. It consists of three alpha and three beta subunits arranged in a hexameric ring. The catalytic sites where adenosine diphosphate and inorganic phosphate are converted into adenosine triphosphate are specifically located on the three beta subunits of the complex.

34. (C) Binding-change mechanism driven by proton flow through the c-ring
The rotation of the gamma subunit in ATP synthase is explained by the binding-change mechanism. As protons pass through the Fo channel, they cause the c-ring and the attached gamma subunit to rotate. This rotation induces sequential conformational changes in the beta subunits of the F_1 portion, enabling the binding of substrates, catalysis of synthesis, and release of ATP.

35. (A) Continuation of electron transport with the dissipation of energy as heat
2,4-Dinitrophenol is a chemical uncoupler that carries protons across the inner mitochondrial membrane, bypassing the ATP synthase. This dissipates the electrochemical gradient without stopping the flow of electrons. Consequently, the energy usually used for ATP synthesis is instead released as heat. While oxygen consumption and electron transport continue or even increase, the production of cellular ATP is inhibited.

36. (B) 2.5
The P/O ratio represents the number of molecules of ATP synthesized per pair of electrons transferred to oxygen. For the oxidation of NADH, the electrons pass through complexes I, III, and IV, resulting in the pumping of ten protons. Since approximately four protons are required to synthesize and export one ATP, the

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ANSWERS

1. (A) A reaction with a negative change in standard free energy
An exergonic reaction is a chemical process where the change in the free energy is negative, indicating that the reaction is thermodynamically favorable and occurs spontaneously. In biological systems, these reactions release energy that can be utilized to perform cellular work. This process results in the products having lower free energy than the initial reactants.

2. (C) The exact reduction potential at non-standard physiological conditions
The Nernst equation relates the reduction potential of an electrochemical cell to the standard electrode potential, temperature, and activities of the chemical species undergoing oxidation and reduction. In biochemistry, it allows for the calculation of the actual reduction potential under physiological conditions where concentrations and pH typically differ from the standard state values of one molarity.

3. (A) Its hydrolysis provides the necessary free energy to drive thermodynamically unfavorable reactions
Adenosine triphosphate acts as the primary energy currency within living organisms by linking energy-releasing catabolic pathways to energy-consuming anabolic processes. The hydrolysis of its high-energy phosphoanhydride bonds releases substantial free energy. This released energy is then used to drive endergonic reactions that would otherwise be thermodynamically impossible to proceed under standard physiological conditions without this external input.

4. (D) A highly positive redox potential indicates a strong tendency to donate electrons
Standard reduction potential measures the tendency of a chemical species to be reduced by gaining electrons. A more negative potential indicates a greater tendency to lose electrons and act as a reducing agent. Conversely, a highly positive potential signifies a strong affinity for electrons, identifying the species as a potent oxidizing agent that readily accepts electrons from others.

5. (B) The natural logarithm of the equilibrium constant
The standard free energy change of a chemical reaction is a thermodynamic property directly related to its equilibrium constant. This relationship is mathematically expressed through a logarithmic function involving the gas constant and absolute temperature. Specifically, the value of the free energy change is proportional to the natural logarithm of the ratio of products to reactants at equilibrium.

6. (C) The phosphorylation of glucose to glucose-6-phosphate driven by ATP hydrolysis
Thermodynamic coupling occurs when the energy released from an exergonic reaction is used to drive an endergonic process. The phosphorylation of glucose is a non-spontaneous reaction that requires an input of energy. By pairing this reaction with the highly exergonic hydrolysis of ATP, the overall net change in free energy becomes negative, allowing the metabolic sequence to proceed.

7. (D) Negative, indicating the process is exergonic
For any metabolic pathway to function spontaneously in a specific direction, the total change in Gibbs free energy must be negative. This negative value indicates that the process is exergonic, meaning it releases energy rather than requiring it. Systems always move toward a state of lower free energy, ensuring the reaction proceeds forward without needing additional external energy.

8. (A) NAD+ / NADH
In the mitochondrial electron transport chain, electrons move along a gradient of increasing reduction potential. Nicotinamide adenine dinucleotide has the most negative standard reduction potential among the common biological carriers, meaning it has the lowest affinity for electrons. This property allows it to serve as a high-energy electron donor, initiating the flow of electrons toward oxygen.

9. (B) -30.5 kJ/mol
The hydrolysis of the terminal phosphoanhydride bond in adenosine triphosphate is a highly

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exergonic reaction. Under standard biochemical conditions, which include a pH of seven, this reaction releases approximately thirty point five kilojoules per mole of free energy. This specific energy value is fundamental to understanding how cellular processes are powered and how metabolic equilibrium is maintained in vivo.

10. (C) A is true but R is false.
Adenosine triphosphate is considered thermodynamically unstable because its hydrolysis releases significant energy, yet it is kinetically stable because the reaction occurs very slowly without enzymes. The reason provided is incorrect because the activation energy for this bond cleavage is actually quite high. This high energy barrier prevents the spontaneous breakdown of energy reserves in the absence of catalysis.

11. (A) Resonance stabilization of the resulting orthophosphate
The high negative free energy released during the hydrolysis of adenosine triphosphate is primarily attributed to several factors. These include the relief of electrostatic repulsion between negatively charged phosphate groups and the increased resonance stabilization of the resulting orthophosphate product. Resonance allows the electrons to be delocalized over multiple oxygen atoms, creating a more stable and lower-energy state than ATP.

12. (C) Hydrolysis is followed by rapid enol-to-keto tautomerization
Phosphoenolpyruvate is one of the highest-energy compounds found in biological systems. Its high group transfer potential stems from the fact that the phosphate group traps the molecule in a less stable enol form. Upon hydrolysis, the resulting pyruvate can spontaneously tautomerize into a much more stable keto form, a transition that releases a large amount of free energy.

13. (D) Phosphocreatine
Phosphocreatine serves as a rapidly mobilizable reserve of high-energy phosphates in skeletal muscle and brain tissue. During periods of high energy demand, the enzyme creatine kinase transfers a phosphate group from phosphocreatine to ADP to regenerate ATP. This system provides a critical temporal buffer to maintain constant ATP levels before slower metabolic pathways like glycolysis or oxidative phosphorylation accelerate.

14. (C) They lack the resonance stabilization present in oxygen esters, making their hydrolysis highly exergonic
Thioesters like acetyl-coenzyme A are high-energy intermediates because the sulfur-carbon bond lacks the significant resonance stabilization found in traditional oxygen esters. Because the larger sulfur atom does not overlap its orbitals effectively with the carbonyl group, the ground state energy of a thioester is higher. Consequently, the hydrolysis of a thioester releases more free energy than an equivalent oxygen ester.

15. (B) Substrate-level phosphorylation during glycolysis
In the glycolytic pathway, 1,3-bisphosphoglycerate is a high-energy intermediate produced during the oxidation of glyceraldehyde-3-phosphate. Its high phosphoryl transfer potential is utilized by the enzyme phosphoglycerate kinase to transfer a phosphate group directly to adenosine diphosphate. This specific reaction represents the first substrate-level phosphorylation step in glycolysis, resulting in the net production of adenosine triphosphate for the cell.

16. (D) Phosphoenolpyruvate
Among various biological molecules, phosphoenolpyruvate possesses one of the highest standard free energies of hydrolysis, valued at approximately negative sixty-one point nine kilojoules per mole. This value is significantly higher than that of adenosine triphosphate. The extreme instability of the enol phosphate bond makes it an exceptionally potent phosphoryl group donor, capable of driving the synthesis of ATP.

17. (A) Succinyl-CoA
During the citric acid cycle, the conversion of succinyl-coenzyme A to succinate is a key step that facilitates the synthesis of a high-energy nucleoside triphosphate. The cleavage of the high-energy thioester bond provides sufficient free energy to drive the phosphorylation of adenosine diphosphate to adenosine triphosphate or guanosine diphosphate to guanosine triphosphate, depending on the specific tissue isoform.

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18. (C) The resonance stabilization of the resulting products is much greater
The hydrolysis of phosphocreatine is thermodynamically favored due to the high resonance stabilization of the resulting products, particularly the creatine molecule and the inorganic phosphate. When the bond is cleaved, the electrons can be delocalized across the guanidinium group, significantly lowering the overall energy of the system. This release of energy makes phosphocreatine an effective donor for ATP regeneration.

19. (A) Strong electrostatic repulsion between the negatively charged oxygen atoms at physiological pH
The structural basis for the high-energy nature of phosphoanhydride bonds in adenosine triphosphate is primarily the intense electrostatic repulsion between its negatively charged oxygen atoms. At physiological pH, the phosphate groups carry multiple negative charges that are forced into close proximity. Breaking these bonds relieves this repulsion, leading to a much more stable state and releasing significant free energy.

20. (A) P-2, Q-3, R-4, S-1
The mitochondrial electron transport chain consists of four major complexes with specific prosthetic groups. Complex I uses flavin mononucleotide and iron-sulfur clusters. Complex II contains flavin adenine dinucleotide and iron-sulfur clusters. Complex III involves multiple hemes and iron-sulfur proteins. Finally, complex IV utilizes heme a and a3 along with copper centers to facilitate the final reduction of molecular oxygen.

21. (B) Complex II
Within the mitochondrial electron transport chain, complexes I, III, and IV act as proton pumps that establish the electrochemical gradient across the inner membrane. Complex II, also known as succinate dehydrogenase, transfers electrons from succinate to ubiquinone but does not possess the structural mechanism required to pump protons. Consequently, it contributes less to the total proton motive force.

22. (C) To shuttle electrons between Complex III and Complex IV
Cytochrome c is a small, soluble heme protein located in the intermembrane space of the mitochondria. Its primary role is to serve as a mobile electron carrier that shuttles single electrons from complex III to complex IV. Unlike other components of the chain that are embedded in the lipid bilayer, it moves along the surface of the inner mitochondrial membrane.

23. (D) Antimycin A
Antimycin A is a potent inhibitor that specifically binds to the Qi site of cytochrome b within complex III. By blocking the transfer of electrons from heme b to ubiquinone, it halts the Q-cycle and effectively stops the flow of electrons through the respiratory chain. This inhibition prevents the formation of the proton gradient necessary for mitochondrial ATP synthesis.

24. (C) 4
The complete reduction of one molecule of diatomic oxygen to two molecules of water is a four-electron process. This reaction occurs at the binuclear center of complex IV, also known as cytochrome c oxidase. To prevent the release of toxic reactive oxygen species, the enzyme holds the oxygen tightly until all four electrons and four protons are successfully added.

25. (B) Ubiquinone (Coenzyme Q)
Ubiquinone, or coenzyme Q, is a unique electron carrier characterized by its hydrophobic isoprenoid tail, which makes it highly soluble within the lipid bilayer of the inner mitochondrial membrane. This lipid solubility allows it to diffuse freely through the membrane, effectively carrying electrons between complex I or complex II and complex III, acting as a critical mobile link.

26. (B) Q-cytochrome c oxidoreductase
The Q-cycle is a complex series of electron transfers that occurs at complex III, also known as the cytochrome bc1 complex or Q-cytochrome c oxidoreductase. This cycle is essential for doubling the number of protons pumped per pair of electrons transferred. It involves the sequential oxidation and reduction of ubiquinone at two distinct sites within the protein complex.

27. (A) The reduced form of Cytochrome a3 in Complex IV
Carbon monoxide exerts its toxic effects by binding with high affinity to the reduced iron atom in the heme a3 center of cytochrome c oxidase. This binding competes with oxygen, the natural substrate, thereby blocking the final

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(B) I and II
(C) II and III
(D) I, II and III

2009

271. Transamination involves a ping-pong kinetic mechanism. During the reaction, the PLP cofactor transiently becomes:
(A) Biocytin
(B) Pyridoxamine phosphate (PMP)
(C) Tetrahydrofolate
(D) Pyridoxic acid

2002

272. In the context of nitrogen metabolism, urea is relatively safe to transport in the blood because it is:
(A) Highly charged and impermeable to membranes
(B) Bound tightly to serum albumin
(C) Highly lipophilic
(D) Neutral and highly water-soluble

2015

273. Hyperammonemia leads to a depletion of alpha-ketoglutarate, which most directly impairs:
(A) The Citric Acid Cycle
(B) Glycolysis
(C) The Urea Cycle
(D) The Pentose Phosphate Pathway

2016

274. The primary defect in Alkaptonuria prevents the breakdown of homogentisic acid. Homogentisic acid is an intermediate in the catabolism of:
(A) Tryptophan
(B) Methionine
(C) Tyrosine
(D) Histidine

2018

275. Phenylpyruvate, a toxic metabolite in PKU, is formed via the transamination of:
(A) Phenylalanine
(B) Tyrosine
(C) Alanine
(D) Homogentisic acid

2025

276. Aspartate provides which atom(s) to the urea molecule?
(A) The carbon atom
(B) Both nitrogen atoms
(C) The oxygen atom
(D) One nitrogen atom

2003

277. The urea cycle is linked to the TCA cycle via the "aspartate-argininosuccinate shunt." Which intermediate bridges these two cycles?
(A) Citrate
(B) Fumarate
(C) Succinyl-CoA
(D) Isocitrate

2024

278. The regulation of the urea cycle in the short term relies solely on the activation of CPS-I by:
(A) Citrulline
(B) Argininosuccinate
(C) N-acetylglutamate
(D) Fumarate

2019

279. Tyrosine is an essential precursor for the synthesis of:
(A) Serotonon and Melatonin
(B) GABA and Histamine
(C) Porphyrins and Creatine
(D) Epinephrine and Melanin

2022

280. Consider the following statements about purine and pyrimidine metabolism:
I. Purine rings are built directly upon a PRPP molecule.
II. Pyrimidine rings are synthesized prior to attachment to PRPP.
III. HGPRT is responsible for salvaging pyrimidines.
IV. Uric acid is the end product of pyrimidine degradation.
Which of the above statement(s) is/are correct?
(A) I and II
(B) III and IV
(C) I and III
(D) II and IV

2010

281. The rate-limiting step of de novo pyrimidine synthesis in mammals is catalyzed by:
(A) Aspartate transcarbamoylase
(B) Carbamoyl phosphate synthetase II (CPS-II)
(C) Thymidylate synthase
(D) Dihydroorotase

2014

282. During the synthesis of dTMP, the methylene group donated by N5,$N_1$0-methylene-THF is simultaneously reduced to a methyl group. What happens to the folate coenzyme?

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standard consensus value for the NADH ratio is 2.5.

37. (B) Oligomycin
Oligomycin is a macrolide antibiotic that acts as a specific inhibitor of ATP synthase. It binds directly to the Fo subunit, blocking the channel through which protons return to the mitochondrial matrix. By preventing proton flow, it halts the rotation of the enzyme and subsequently stops the synthesis of ATP, effectively coupling the inhibition to the respiratory chain.

38. (C) Dissipate the proton gradient to drive thermogenesis
Thermogenin, also known as uncoupling protein 1, is found in the inner mitochondrial membrane of brown adipose tissue. It functions as a proton channel that allows protons to leak back into the matrix without passing through ATP synthase. This process dissipates the electrochemical gradient as heat rather than capturing it as ATP, helping mammals maintain body temperature during cold.

39. (D) Rotation of gamma inducing conformational changes in beta
According to the binding-change mechanism, the release of newly synthesized ATP from the catalytic site of the beta subunit is the energy-requiring step. This release is driven by the physical rotation of the asymmetric gamma subunit. As it rotates, it forces the beta subunit into a conformation with very low affinity for ATP, allowing the molecule to dissociate.

40. (C) I and IV
Hexokinase undergoes a significant conformational change upon binding glucose to prevent the unproductive hydrolysis of ATP. Pyruvate kinase catalyzes the final step of glycolysis, which is the second substrate-level phosphorylation event producing ATP. Statement II is incorrect because PFK-1 is irreversible, and statement III is wrong because aldolase produces two different three-carbon sugars: DHAP and glyceraldehyde-3-phosphate.

41. (B) Phosphofructokinase-1 (PFK-1)
Phosphofructokinase-1 catalyzes the conversion of fructose-6-phosphate to fructose-1,6-bisphosphate using ATP. This reaction is widely considered the most important rate-limiting and committed step of glycolysis. It is highly regulated by multiple allosteric effectors, ensuring that the flux through the pathway is precisely adjusted according to the energy status and metabolic needs of the cell.

42. (B) Activated by AMP and inhibited by ATP and citrate
Phosphofructokinase-1 is allosterically regulated to reflect the energy state of the cell. High levels of ATP and citrate signify abundant energy and biosynthetic precursors, thus inhibiting the enzyme to slow glycolysis. Conversely, high levels of AMP indicate a low energy charge, acting as a potent activator to increase the rate of ATP production through the glycolytic pathway.

43. (A) The Cori cycle
The Cori cycle is a metabolic pathway that involves the exchange of metabolites between skeletal muscle and the liver. During intense exercise, muscles produce lactate via anaerobic glycolysis. This lactate is released into the bloodstream and taken up by the liver, where it is converted back into glucose through gluconeogenesis. The regenerated glucose then returns to the muscle.

44. (C) Glucose-6-phosphatase
In the liver and kidneys, glucose-6-phosphatase is the enzyme that allows for the final step of gluconeogenesis, bypassing the irreversible hexokinase reaction of glycolysis. It hydrolyzes glucose-6-phosphate into free glucose and inorganic phosphate. This enzyme is essential for the release of glucose into the blood, helping to maintain stable blood sugar levels during fasting or between meals.

45. (D) Pyruvate carboxylase and PEP carboxykinase
The conversion of pyruvate to phosphoenolpyruvate is a two-step process in gluconeogenesis that bypasses the irreversible pyruvate kinase reaction. First, pyruvate carboxylase converts pyruvate into oxaloacetate within the mitochondria. Then, phosphoenolpyruvate carboxykinase converts oxaloacetate into PEP in either the mitochondria or the cytosol. These reactions require the input of energy from both ATP and GTP to proceed.

46. (C) FBPase-2 is phosphorylated, reducing F-2,6-BP levels
Glucagon signaling triggers the phosphorylation of the bifunctional enzyme PFK-2/FBPase-2 via protein kinase A. This phosphorylation

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65. (A) The non-oxidative phase channels sugar phosphates back into glycolysis for complete oxidation
When a cell's need for NADPH exceeds its requirement for ribose-5-phosphate, the pentose phosphate pathway adjusts its flux. The ribose-5-phosphate produced in the oxidative phase is converted by the non-oxidative enzymes back into fructose-6-phosphate and glyceraldehyde-3-phosphate. These intermediates then enter the glycolytic pathway for further oxidation, allowing for the continuous production of NADPH from glucose-6-phosphate.

66. (C) Autocatalytic primer initiating the first glucose polymer chains
Glycogenin is a specialized protein that serves as the primer for the synthesis of new glycogen molecules. It possesses an autocatalytic glucosyltransferase activity that attaches the first few glucose residues from UDP-glucose to a specific tyrosine residue on itself. Once a short chain of approximately eight glucose units is formed, glycogen synthase can then take over and elongate the polymer.

67. (A) UDP-glucose
Uridine diphosphate glucose is the activated form of glucose used as a substrate for the synthesis of glycogen. It is formed from glucose-1-phosphate and UTP in a reaction catalyzed by UDP-glucose pyrophosphorylase. The use of a nucleotide-linked sugar provides the necessary free energy to make the subsequent glycosidic bond formation thermodynamically favorable and essentially irreversible in the cell.

68. (D) Amylo-(1,4 to 1,6)-transglycosylase (Branching enzyme)
While glycogen synthase creates the linear alpha-1,4 glycosidic bonds, the branching enzyme, or amylo-transglycosylase, is responsible for creating the alpha-1,6 linkages. It accomplishes this by transferring a short segment of six or seven glucose residues from the end of a growing chain to a more internal position, thereby increasing the number of non-reducing ends for rapid mobilization.

69. (B) Glucose-1-phosphate
During glycogenolysis, glycogen phosphorylase catalyzes the phosphorolysis of the alpha-1,4 glycosidic bonds starting from the non-reducing ends of the glycogen molecule. This reaction uses inorganic phosphate to cleave the bond, releasing glucose-1-phosphate rather than free glucose. This process conserves the metabolic energy of the glycosidic bond, as the resulting product can be easily converted into glucose-6-phosphate for glycolysis.

70. (A) Both A and R are true and R is the correct explanation of A.
Muscle tissue contains significant glycogen stores but cannot directly release glucose into the bloodstream to maintain systemic levels during fasting. This is because muscle cells lack the enzyme glucose-6-phosphatase, which is required to remove the phosphate group from glucose-6-phosphate. Consequently, the glucose derived from muscle glycogen is trapped within the cell and used exclusively for its own energy needs.

71. (D) PKA phosphorylation inactivates glycogen synthase and activates glycogen phosphorylase
Reciprocal regulation ensures that glycogen synthesis and breakdown do not occur simultaneously. In response to cAMP signaling, protein kinase A phosphorylates both glycogen synthase and phosphorylase kinase. Phosphorylation inactivates glycogen synthase, halting synthesis, while it activates phosphorylase kinase, which then activates glycogen phosphorylase. This coordinated switch efficiently mobilizes glucose reserves when the body requires a rapid increase in energy availability.

72. (A) Protein Phosphatase 1 (PP1)
Protein phosphatase 1 is the primary enzyme responsible for reversing the effects of cAMP-dependent phosphorylation in glycogen metabolism. It dephosphorylates glycogen synthase, thereby activating it, and dephosphorylates both phosphorylase kinase and glycogen phosphorylase, thereby inactivating them. This promotes glycogen storage and inhibits glycogen mobilization, typically occurring in the well-fed state under the influence of insulin signaling.

73. (B) It exhibits bifunctional transferase and alpha-1,6-glucosidase activity
The debranching enzyme is a bifunctional protein required for the complete breakdown of glycogen. It first acts as a transferase, moving a block of three glucose residues from a branch to a nearby non-reducing end. Then, its alpha-1,6-glucosidase

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56. (A) 10
The complete oxidation of one molecule of acetyl-coenzyme A in the citric acid cycle generates three NADH, one FADH2, and one GTP or ATP. Through oxidative phosphorylation, each NADH yields approximately 2.5 ATP, and each FADH2 yields 1.5 ATP. Adding the single GTP results in a total net yield of ten high-energy phosphate bonds.

57. (B) Succinate dehydrogenase
Succinate dehydrogenase is unique among the enzymes of the citric acid cycle because it is physically embedded in the inner mitochondrial membrane. It also functions as complex II of the electron transport chain. It catalyzes the oxidation of succinate to fumarate, directly transferring electrons to its FAD prosthetic group and then to ubiquinone, bypassing the first complex of the chain.

58. (B) NADPH and Ribose-5-phosphate
The oxidative phase of the pentose phosphate pathway consists of three irreversible reactions that convert glucose-6-phosphate into ribulose-5-phosphate. During this process, two molecules of NADPH are generated, providing essential reducing power for biosynthetic reactions and antioxidant defense. The ribulose-5-phosphate is then typically isomerized into ribose-5-phosphate, which serves as a critical precursor for the biosynthesis of nucleotides and nucleic acids.

59. (A) Glucose-6-phosphate dehydrogenase
Glucose-6-phosphate dehydrogenase catalyzes the first step of the pentose phosphate pathway, converting glucose-6-phosphate into 6-phosphogluconolactone. This reaction is the primary rate-limiting and regulatory step of the entire pathway. The enzyme is strongly inhibited by high levels of its product, NADPH, ensuring that the production of reducing equivalents is precisely matched to the metabolic needs of the cell.

60. (A) Glucose-6-phosphate → 6-phosphoglucono-delta-lactone → 6-phosphogluconate → Ribulose-5-phosphate
The oxidative phase of the pentose phosphate pathway follows a specific sequence. First, glucose-6-phosphate is oxidized to 6-phosphoglucono-delta-lactone by glucose-6-phosphate dehydrogenase. This lactone is then hydrolyzed to 6-phosphogluconate by a lactonase. Finally, 6-phosphogluconate undergoes oxidative decarboxylation to form ribulose-5-phosphate, with both oxidation steps producing NADPH as a byproduct. This sequence is essential for generating reducing power and pentose sugars.

61. (D) It maintains glutathione in a reduced state to combat oxidative stress
In red blood cells, the pentose phosphate pathway is the only source of NADPH. This molecule is vital for maintaining glutathione in its reduced form, which is used by glutathione peroxidase to neutralize reactive oxygen species like hydrogen peroxide. Without sufficient NADPH, oxidative stress leads to the denaturation of hemoglobin and the subsequent lysis of the erythrocyte membrane.

62. (B) 2 carbons
Transketolase is a key enzyme in the non-oxidative phase of the pentose phosphate pathway. It facilitates the interconversion of different sugar phosphates by transferring a two-carbon fragment from a ketose donor to an aldose acceptor. This reaction is reversible and allows the cell to adapt the pathway to its specific needs for ribose or glycolytic intermediates.

63. (B) Thiamine pyrophosphate (TPP)
Transketolase requires thiamine pyrophosphate as an essential coenzyme to stabilize the two-carbon carbanion intermediate during the transfer process. A clinical measurement of erythrocyte transketolase activity is often used as a diagnostic tool to assess thiamine nutritional status in humans. A deficiency in this vitamin significantly impairs the non-oxidative phase of the pentose phosphate pathway and overall carbohydrate metabolism.

64. (A) Both A and R are true and R is the correct explanation of A.
Rapidly dividing cells have a high demand for nucleotides to support DNA replication and RNA synthesis. The pentose phosphate pathway is highly active in these cells because it provides ribose-5-phosphate, which is the essential five-carbon sugar backbone for all nucleotides. Therefore, the assertion and the reason are both true and the reason correctly explains the physiological observation.

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83. (A) Palmitic acid (16:0)
The eukaryotic fatty acid synthase is a massive multienzyme complex that repeatedly adds two-carbon units to a growing acyl chain. The process continues until the chain reaches sixteen carbons in length, at which point the thioesterase domain of the complex releases the saturated fatty acid as palmitic acid. Further elongation or desaturation of this product occurs in different cellular compartments.

84. (D) Biotin
Acetyl-coenzyme A carboxylase requires biotin as a vital prosthetic group to facilitate the transfer of a carboxyl group to acetyl-CoA. Biotin is covalently attached to the enzyme and acts as a carrier for the activated carbon dioxide. This ATP-dependent reaction produces malonyl-CoA, which serves as the essential building block and regulator for the entire fatty acid biosynthetic pathway.

85. (B) Citrate
Acetyl-coenzyme A carboxylase is the primary regulatory enzyme of fatty acid synthesis and is allosterically controlled by metabolites. Citrate acts as a potent activator by promoting the polymerization of inactive enzyme dimers into active long filaments. High citrate levels signal that the citric acid cycle is saturated and that there is an abundance of precursors available for biosynthetic processes.

86. (C) Via NADPH from the pentose phosphate pathway and malic enzyme
Fatty acid synthesis requires large amounts of reducing power in the form of NADPH. This cofactor is supplied by two main sources in the cytosol. The pentose phosphate pathway is the major contributor in most tissues. Additionally, the malic enzyme provides significant amounts of NADPH when it converts malate back into pyruvate during the citrate-pyruvate shuttle that exports acetyl-CoA.

87. (B) Carbon 9
Mammalian cells possess fatty acid desaturases that can introduce double bonds at specific positions in the acyl chain, most notably at the delta-nine position. However, they lack the specific enzymes required to introduce double bonds beyond carbon nine toward the methyl end of the molecule. This limitation is why linoleic and linolenic acids are classified as essential fatty acids in the diet.

88. (A) Pantothenic acid
The acyl carrier protein is a small subunit of the fatty acid synthase complex that holds the growing fatty acid chain. It contains a 4-phosphopantetheine prosthetic group derived from the vitamin pantothenic acid. This flexible swinging arm allows the acyl intermediates to be moved between the different active sites of the multienzyme complex during each cycle of the synthesis process.

89. (B) Propionate
In ruminants, very little dietary glucose reaches the small intestine due to fermentation in the rumen. Consequently, these animals are in a state of constant gluconeogenesis to maintain blood sugar levels. Propionate, a three-carbon volatile fatty acid produced by ruminal bacteria, is the only major VFA that can be used for the net synthesis of glucose in the liver.

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90. (A) I, II and III
Ruminant metabolism is characterized by specialized pathways for utilizing volatile fatty acids. Acetate is the primary substrate for lipogenesis. Butyrate is largely converted to beta-hydroxybutyrate by the rumen wall, and propionate enters the citric acid cycle as succinyl-CoA for gluconeogenesis. Statement IV is incorrect because ruminants derive almost all their blood glucose from hepatic gluconeogenesis rather than direct absorption.

91. (A) Both carbons entering the cycle are lost as CO_2 during decarboxylation
Acetate cannot contribute to the net synthesis of glucose because it enters the citric acid cycle as acetyl-coenzyme A. During the cycle, the two carbons of the acetyl group are lost as carbon dioxide before reaching oxaloacetate. Since there is no net gain of carbons that can be diverted to the gluconeogenic pathway, acetate is considered strictly non-glucogenic in animals.

92. (C) The nature of the diet (roughage vs. concentrate ratio)
The relative proportions of acetate, propionate, and butyrate produced in the rumen are primarily determined by the composition of the diet. Forage-based diets rich in cellulose favor the growth of cellulolytic bacteria that produce

activity hydrolyzes the remaining single glucose residue at the branch point, releasing it as free glucose. This allows phosphorylase to continue.

74. (B) Fatty acyl-CoA synthetase (Thiokinase)
Fatty acid activation is the initial step of lipid catabolism and occurs on the outer mitochondrial membrane. The enzyme fatty acyl-coenzyme A synthetase, or thiokinase, catalyzes the condensation of a long-chain fatty acid with coenzyme A to form a fatty acyl-CoA thioester. This two-step reaction requires the hydrolysis of ATP to AMP and pyrophosphate, providing the necessary energy.

75. (A) Carnitine shuttle
Long-chain fatty acyl-coenzyme A molecules cannot directly cross the inner mitochondrial membrane to reach the site of beta-oxidation. They must be transported via the carnitine shuttle system. This involves converting the acyl-CoA into acyl-carnitine by carnitine palmitoyltransferase 1, transporting it across the membrane, and then converting it back into acyl-CoA by carnitine palmitoyltransferase 2 in the matrix.

76. (C) Oxidation by acyl-CoA dehydrogenase
The first step of each cycle of mitochondrial beta-oxidation is the oxidation of the fatty acyl-CoA to form a trans-double bond between the alpha and beta carbons. This reaction is catalyzed by acyl-coenzyme A dehydrogenase and uses FAD as an electron acceptor, producing FADH2. The electrons from FADH2 are then transferred directly to the electron transport chain to generate ATP.

77. (D) Acetyl-CoA and one molecule of Propionyl-CoA
The beta-oxidation of fatty acids with an odd number of carbon atoms proceeds normally until the final cycle. In this last step, the remaining five-carbon intermediate is cleaved into one molecule of acetyl-coenzyme A and one molecule of propionyl-coenzyme A. While acetyl-CoA enters the citric acid cycle directly, propionyl-CoA must undergo a specialized three-step pathway to be converted into succinyl-CoA.

78. (C) Enoyl-CoA isomerase
The beta-oxidation of unsaturated fatty acids encounters cis-double bonds that cannot be acted upon by the standard enoyl-CoA hydratase enzyme. Enoyl-coenzyme A isomerase is required to shift the position of the double bond and convert it from the cis to the trans configuration. Once converted, the fatty acid intermediate can continue through the remaining steps of the beta-oxidation pathway.

79. (C) 106 ATP
The complete oxidation of one molecule of palmitic acid, a sixteen-carbon saturated fatty acid, involves seven rounds of beta-oxidation, producing eight acetyl-CoA, seven NADH, and seven FADH2. After accounting for the initial activation cost of two high-energy phosphate bonds, the subsequent oxidation of these products in the TCA cycle and electron transport chain yields a net total of approximately 106 ATP.

80. (A) P-4, Q-1, R-2, S-3
Lipid metabolism involves diverse enzymes with specific functions. Acetyl-CoA carboxylase catalyzes the committed step of fatty acid synthesis. Acyl-CoA dehydrogenase performs the initial oxidation in mitochondrial beta-oxidation. Carnitine palmitoyltransferase 1 is essential for the transport of fatty acids into the mitochondria. Hormone-sensitive lipase is the key enzyme responsible for mobilizing stored triacylglycerols from adipose tissue into free fatty acids.

81. (A) Cytosol
In most tissues, de novo fatty acid biosynthesis occurs primarily in the cytosol. This spatial separation from the site of beta-oxidation, which happens in the mitochondrial matrix, allows for the independent and reciprocal regulation of the two pathways. The process uses acetyl-CoA transported from the mitochondria in the form of citrate and requires significant amounts of NADPH as a reductant.

82. (C) Malonyl-CoA
Although acetyl-coenzyme A is the starting unit for fatty acid synthesis, the direct donor of two-carbon units for the elongation steps is malonyl-coenzyme A. It is produced by the carboxylation of acetyl-CoA in a reaction that requires ATP and biotin. The decarboxylation of the malonyl group during the condensation step provides the thermodynamic drive needed to extend the growing chain.

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inhibits the kinase activity and activates the phosphatase activity, leading to a decrease in the concentration of fructose-2,6-bisphosphate. Since this molecule is a potent activator of glycolysis and an inhibitor of gluconeogenesis, its reduction effectively shifts the hepatic metabolism toward glucose production.

47. (B) Glyceraldehyde-3-phosphate dehydrogenase
The oxidation of glyceraldehyde-3-phosphate to 1,3-bisphosphoglycerate is the only step in glycolysis that generates NADH. This reaction, catalyzed by glyceraldehyde-3-phosphate dehydrogenase, involves the transfer of a hydride ion to NAD+ and the incorporation of an inorganic phosphate group. The produced NADH must be subsequently reoxidized to maintain the glycolytic flux under both aerobic and anaerobic conditions.

48. (D) Glucokinase is exclusively expressed in skeletal muscle
Hexokinase and glucokinase are isozymes that catalyze the phosphorylation of glucose. Glucokinase, or hexokinase IV, is primarily expressed in the liver and pancreatic beta cells, not in skeletal muscle. It has a higher K_m for glucose, meaning it is active only when glucose levels are high. Unlike other hexokinases, it is not inhibited by its product, glucose-6-phosphate.

49. (A) 2 ATP
Under anaerobic conditions, glucose is converted to lactate through the process of glycolysis. Although four ATP molecules are produced during the payoff phase, two ATP molecules are consumed during the initial preparatory phase. This results in a net yield of exactly two ATP molecules per glucose molecule. This pathway allows for rapid energy production when oxygen availability is limited.

50. (B) I, II, IV, V
The pyruvate dehydrogenase complex catalyzes the irreversible oxidative decarboxylation of pyruvate to acetyl-coenzyme A, linking glycolysis to the citric acid cycle. It requires several cofactors, including thiamine pyrophosphate and lipoic acid, which carries acyl groups. Statement III is incorrect because the complex is actually inhibited by high ratios of ATP to ADP, signaling that the cell has sufficient energy.

51. (A) High levels of Acetyl-CoA and NADH
The activity of the pyruvate dehydrogenase complex is tightly regulated by its products. High concentrations of acetyl-coenzyme A and NADH act as potent allosteric inhibitors of the enzyme complex. This feedback inhibition ensures that pyruvate is not unnecessarily converted into acetyl-CoA when the citric acid cycle is saturated or when the cell already possesses a high energy charge.

52. (D) Succinyl-CoA synthetase
Succinyl-coenzyme A synthetase, also known as succinate thiokinase, catalyzes the only reaction in the citric acid cycle that directly results in the formation of a high-energy nucleoside triphosphate. The energy released from the cleavage of the thioester bond in succinyl-CoA is used to phosphorylate GDP to GTP or ADP to ATP, depending on the specific tissue and enzyme isoform.

53. (B) Oxaloacetate
Pyruvate carboxylase catalyzes an important anaplerotic reaction that replenishes oxaloacetate within the mitochondrial matrix. By adding a carbon dioxide molecule to pyruvate, it ensures that there is a sufficient supply of this four-carbon intermediate to keep the citric acid cycle running efficiently. This reaction is particularly vital when cycle intermediates are being diverted for biosynthetic pathways like gluconeogenesis.

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54. (C) Oxidation of malate to oxaloacetate
The oxidation of malate to oxaloacetate, catalyzed by malate dehydrogenase, is highly endergonic under standard conditions. However, the reaction proceeds forward in the cell because the product, oxaloacetate, is rapidly consumed by the next step of the cycle, citrate synthase. This continuous removal of the product keeps the actual concentration low enough to make the reaction thermodynamically favorable.

55. (D) Aconitase
Fluorocitrate is a toxic metabolite formed from fluoroacetate. It acts as a potent competitive inhibitor of aconitase, the enzyme responsible for the isomerization of citrate to isocitrate in the citric acid cycle. By blocking this step, fluorocitrate causes a massive accumulation of citrate and halts the entire cycle, leading to a failure in cellular energy production and toxicity.

high levels of acetate. In contrast, concentrate-based diets rich in starch promote the growth of amylolytic bacteria, leading to a significant increase in propionate production.

93. (D) Propionate
When a ruminant is fed a high-concentrate diet, the abundance of easily fermentable carbohydrates like starch leads to a shift in the microbial population. Amylolytic bacteria become more dominant, resulting in a higher production of propionate relative to acetate. This shift is beneficial for energy efficiency and growth, as propionate is a primary precursor for glucose synthesis in the animal.

94. (D) Both Biotin and Vitamin B_{12}
The conversion of propionate to succinyl-CoA requires two specific enzymatic steps involving vitamin-derived cofactors. First, propionyl-CoA carboxylase requires biotin to form methylmalonyl-CoA. Subsequently, methylmalonyl-CoA mutase requires deoxyadenosylcobalamin, a form of vitamin B_{12}, to rearrange the carbon skeleton into succinyl-CoA. Both vitamins are essential for the utilization of propionate as a glucogenic substrate in ruminants and other mammals.

95. (B) It functions as a primary energy substrate for the heart and skeletal muscle
Beta-hydroxybutyrate is a major ketone body produced by the rumen epithelium from fermented butyrate. It is released into the portal circulation and serves as an important energy substrate for peripheral tissues, including the heart and skeletal muscle. These tissues can easily oxidize beta-hydroxybutyrate back to acetyl-coenzyme A, which then enters the citric acid cycle to generate ATP via oxidative phosphorylation.

96. (D) When beta-oxidation produces acetyl-CoA faster than TCA cycle capacity
Ketogenesis primarily occurs in the liver when there is an overabundance of acetyl-coenzyme A, typically resulting from rapid beta-oxidation of fatty acids during fasting or uncontrolled diabetes. If the amount of acetyl-CoA exceeds the capacity of the citric acid cycle to oxidize it, or if oxaloacetate levels are depleted, the liver diverts the excess acetyl-CoA into the synthesis of ketone bodies.

97. (A) Alpha-ketoglutarate
The term ketone bodies refers to three specific molecules produced by the liver during periods of high fat metabolism: acetoacetate, beta-hydroxybutyrate, and acetone. Although beta-hydroxybutyrate is technically a hydroxy acid rather than a ketone, it is classically grouped with the others. Alpha-ketoglutarate is an intermediate of the citric acid cycle and is not considered a ketone body in clinical biochemistry.

98. (C) HMG-CoA synthase
The mitochondrial isoform of 3-hydroxy-3-methylglutaryl-coenzyme A synthase is the rate-limiting enzyme for the synthesis of ketone bodies in the liver. It catalyzes the condensation of acetoacetyl-CoA with a third molecule of acetyl-CoA to form HMG-CoA. This enzyme is distinct from the cytosolic isoform that participates in the cholesterol biosynthetic pathway, allowing for independent regulation of these two metabolic fates.

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99. (A) It lacks the enzyme beta-ketoacyl-CoA transferase (thiophorase)
Although the liver is the primary site for ketone body synthesis, it cannot utilize them as an energy source. Hepatocytes lack the enzyme beta-ketoacyl-coenzyme A transferase, also known as thiophorase. This enzyme is essential for activating acetoacetate into acetoacetyl-CoA by transferring a coenzyme A group from succinyl-CoA. This metabolic design ensures that ketone bodies are exported to peripheral tissues.

100. (D) Persistent negative energy balance requiring massive lipid mobilization
Clinical ketosis in high-yielding dairy cows occurs during early lactation when the energy demand for milk production exceeds the animal's dietary energy intake. This negative energy balance triggers the massive mobilization of fatty acids from adipose tissue. The resulting influx of fatty acids into the liver leads to excessive production of ketone bodies, which can accumulate to toxic levels in the blood.

101. (B) Butyrate
Among the volatile fatty acids produced in the rumen, butyrate is uniquely ketogenic. As it is absorbed across the rumen wall, a significant portion is converted directly into the ketone body beta-hydroxybutyrate. High levels of butyrate fermentation, often associated with

to form alanine via transamination. Alanine is then released into the bloodstream and transported to the liver. This mechanism, known as the glucose-alanine cycle, allows the muscle to export nitrogen in a non-toxic form while also providing the liver with a carbon skeleton for gluconeogenesis.

121. (A) Transport nitrogen to the liver and supply skeletons for gluconeogenesis
The glucose-alanine cycle serves two primary metabolic purposes during periods of muscle protein breakdown. First, it provides a safe way to transport excess nitrogen from the muscle to the liver for urea synthesis. Second, it delivers the three-carbon skeleton of pyruvate, in the form of alanine, to the liver to be used as a substrate for gluconeogenesis.

122. (B) Hydrolyze glutamine to yield glutamate and free ammonia for the urea cycle
Glutaminase is an enzyme found in the mitochondria of hepatocytes and renal tubular cells. Its primary role in the liver is to hydrolyze glutamine that has been transported from peripheral tissues, releasing free ammonia and glutamate. The released ammonia then directly enters the urea cycle for detoxification, while the glutamate can undergo further deamination to provide more ammonia if needed.

123. (B) Liver
The urea cycle is the principal mechanism for the detoxification of ammonia in ureotelic animals. While various enzymes of the cycle can be found in other tissues, the complete set of enzymes required for the entire pathway is expressed exclusively in the liver. Therefore, the liver is the only organ capable of synthesizing urea for excretion by the kidneys.

124. (A) Carbamoyl phosphate synthetase I
Carbamoyl phosphate synthetase I is the regulatory and rate-limiting enzyme of the urea cycle. Located in the mitochondrial matrix, it catalyzes the condensation of free ammonium ions with bicarbonate to form carbamoyl phosphate. This reaction is highly energy-intensive, requiring the consumption of two molecules of ATP. The activity of this enzyme is strictly dependent on the presence of an activator.

125. (C) Initial mitochondrial reactions followed by completion in the cytosol
The urea cycle is a compartmentalized metabolic pathway. The first two reactions, catalyzed by carbamoyl phosphate synthetase 1 and ornithine transcarbamylase, occur within the mitochondrial matrix. The resulting citrulline is then transported out into the cytosol, where the remaining three reactions take place to complete the formation of urea and regenerate ornithine, which then returns to the mitochondria.

126. (D) N-acetylglutamate
Carbamoyl phosphate synthetase 1 has an absolute requirement for N-acetylglutamate as an allosteric activator. Without this molecule, the enzyme is virtually inactive. The levels of N-acetylglutamate rise when amino acid catabolism increases, effectively signaling the need for enhanced urea cycle activity. This regulatory mechanism ensures that the rate of urea synthesis is precisely matched to the load of nitrogen.

127. (C) Free ammonia and aspartate
Each molecule of urea contains two nitrogen atoms that are incorporated into the structure at different points in the cycle. The first nitrogen atom enters the cycle in the form of free ammonia via the carbamoyl phosphate synthetase 1 reaction. The second nitrogen atom is donated by the amino acid aspartate during the formation of argininosuccinate in the cytosol.

128. (B) Fumarate
The cleavage of argininosuccinate is catalyzed by the enzyme argininosuccinate lyase in the cytosol. This reaction produces arginine, which continues in the urea cycle, and fumarate. The fumarate produced serves as a critical link between the urea cycle and the citric acid cycle, as it can be converted into malate and then oxaloacetate to support various metabolic pathways.

129. (C) 4
The synthesis of one molecule of urea is energetically expensive, consuming a total of four high-energy phosphate bonds. Two ATP molecules are used to synthesize carbamoyl phosphate, and one ATP is converted to AMP and pyrophosphate during the synthesis of argininosuccinate. Since the hydrolysis of pyrophosphate provides additional energy, the total energetic cost is equivalent to four ATP.

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the most abundant phospholipid in mammalian membranes.

111. (D) Cardiolipin
Cardiolipin, or diphosphatidylglycerol, is a unique double phospholipid almost exclusively found in the inner mitochondrial membrane. It plays a critical structural and functional role in stabilizing the complexes of the electron transport chain and is essential for the efficient production of ATP. Abnormalities in cardiolipin levels or structure are associated with several mitochondrial diseases and impaired cellular energy metabolism.

112. (B) Pulmonary surfactant
Dipalmitoylphosphatidylcholine is a specialized phospholipid that serves as the primary functional component of pulmonary surfactant. It is secreted by type II alveolar cells in the lungs to reduce surface tension at the air-water interface. This action prevents the collapse of the alveoli during expiration and reduces the work required for breathing, making it indispensable for proper respiratory function.

113. (D) Reversible transfer of an alpha-amino group to an alpha-keto acid
Transamination is the primary mechanism for the redistribution of nitrogen between amino acids and keto acids. It involves the reversible transfer of an alpha-amino group from an amino acid to an alpha-keto acid, catalyzed by enzymes called aminotransferases. This process does not result in the net loss of nitrogen but rather allows the cell to synthesize non-essential amino acids.

114. (A) Pyridoxal phosphate (PLP)
All aminotransferases require pyridoxal phosphate, a derivative of vitamin B_6, as an essential prosthetic group. During the reaction, PLP is covalently bound to the enzyme and acts as a carrier for the amino group. It transiently converts to pyridoxamine phosphate as it accepts the amino group from the donor amino acid and subsequently releases it to the acceptor keto acid.

115. (C) Alpha-ketoglutarate
Alpha-ketoglutarate is the most common alpha-keto acid acceptor in transamination reactions across various tissues. By accepting an amino group from most amino acids, it is converted into glutamate. Glutamate then serves as a central hub in nitrogen metabolism, as its amino group can be subsequently removed as free ammonia via oxidative deamination or used for the synthesis of other nitrogenous compounds.

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116. (A) Both A and R are true and R is the correct explanation of A.
Pyridoxal phosphate is an exceptionally versatile cofactor in amino acid metabolism. It functions by forming a covalent Schiff base intermediate with the alpha-amino group of the substrate. This structure acts as an effective electron sink, stabilizing the carbanion formed during the reaction. Consequently, the assertion and the reason are both true, and the reason correctly explains the mechanism of catalysis.

117. (A) Glutamate dehydrogenase
In the liver, glutamate dehydrogenase is the primary enzyme responsible for the oxidative deamination of glutamate. This reaction removes the amino group as free ammonia while simultaneously reducing NAD+ or NADP+ to NADH or NADPH. This process is crucial because it provides the ammonia required for the urea cycle and regenerates alpha-ketoglutarate, which can then participate in further transamination reactions.

118. (B) Either NAD+ or NADP+ as a coenzyme
Glutamate dehydrogenase is unique among metabolic enzymes because it can utilize either nicotinamide adenine dinucleotide or its phosphorylated form as a coenzyme. This dual specificity allows the enzyme to participate in both catabolic processes, where it produces NADH and ammonia, and anabolic processes, where it can potentially utilize NADPH for the reductive amination of alpha-ketoglutarate to form glutamate.

119. (C) As glutamine
Ammonia is highly toxic to biological tissues, especially the brain. To safely transport it to the liver for excretion, many extrahepatic tissues combine free ammonia with glutamate to form glutamine, catalyzed by glutamine synthetase. Glutamine is a neutral, non-toxic amino acid that can travel safely through the blood. Once it reaches the liver, it is hydrolyzed back into glutamate.

120. (D) Alanine
In skeletal muscle, amino groups derived from protein catabolism are transferred to pyruvate

poor-quality silage or certain dietary shifts, can therefore contribute to the development of ketosis in ruminants by increasing the systemic ketone load.

102. (C) Succinyl-CoA
To utilize acetoacetate as a fuel, extrahepatic tissues must first activate it to acetoacetyl-CoA. This reaction is catalyzed by the enzyme thiophorase, which uses succinyl-coenzyme A as the donor of the coenzyme A group. Once activated, acetoacetyl-CoA is cleaved by a thiolase into two molecules of acetyl-CoA, which then enter the citric acid cycle to generate cellular energy in the form of ATP.

103. (A) III, II, I, IV
The biosynthesis of cholesterol proceeds through several distinct stages. It begins with the condensation of acetyl-CoA units to form HMG-CoA. Next, HMG-CoA is reduced to mevalonate. Mevalonate is then converted into isoprenoid units that condense to form squalene. Finally, squalene undergoes cyclization to form lanosterol, which is subsequently converted through multiple steps into the final product, cholesterol.

104. (A) HMG-CoA reductase
HMG-CoA reductase is the primary rate-limiting and committed enzyme in the de novo cholesterol biosynthetic pathway. Located in the endoplasmic reticulum, it catalyzes the four-electron reduction of HMG-CoA to mevalonate using NADPH. Because cholesterol is essential but also potentially toxic in excess, this enzyme is subject to intensive regulation by transcriptional control, protein degradation, and reversible covalent modification.

105. (A) High intracellular levels of cholesterol
HMG-CoA reductase is tightly regulated through a feedback mechanism. High intracellular levels of cholesterol lead to the inhibition of the enzyme by promoting its rapid degradation and by suppressing the transcription of its gene through the SREBP pathway. This ensures that the cell does not synthesize more cholesterol than is required, thereby maintaining homeostatic levels of this vital membrane component.

106. (B) Ubiquinone (Coenzyme Q)
The isoprenoid pathway, which branches from the cholesterol biosynthetic pathway at the level of farnesyl pyrophosphate, provides essential building blocks for several other biological molecules. One of the most important of these is ubiquinone, also known as coenzyme Q, which is a vital electron carrier in the mitochondrial respiratory chain. Other products include dolichol and certain modified proteins.

107. (B) Phosphatidate
Phosphatidate, or diacylglycerol-3-phosphate, is the central intermediate in the biosynthesis of both triacylglycerols and complex phosphoglycerides. It is formed by the sequential acylation of glycerol-3-phosphate with two fatty acyl-CoA molecules. Depending on the cell's requirements, phosphatidate can then be activated with CTP to form CDP-diacylglycerol or dephosphorylated to diacylglycerol for the synthesis of various membrane lipids.

108. (A) Serine
The biosynthesis of sphingolipids begins in the endoplasmic reticulum with the condensation of palmitoyl-coenzyme A and the amino acid serine. This reaction is catalyzed by the enzyme serine palmitoyltransferase and requires pyridoxal phosphate as a coenzyme. The resulting intermediate is subsequently reduced and acylated to form ceramide, which serves as the structural core for all complex sphingolipids and glycosphingolipids.

109. (C) Sphingosine backbone linked to a fatty acid through an amide bond
Structurally, a ceramide is composed of a long-chain amino alcohol backbone called sphingosine to which a fatty acid is attached via an amide bond at the carbon-2 position. This hydrophobic molecule acts as the fundamental building block for more complex sphingolipids, such as sphingomyelin and various cerebrosides, which are essential components of the lipid bilayer in eukaryotic cell membranes.

110. (A) II, III, I, IV
The synthesis of phosphatidylcholine via the Kennedy pathway follows a specific order of intermediates. Choline is first phosphorylated by choline kinase to form phosphocholine. Phosphocholine then reacts with CTP to produce the activated intermediate CDP-choline. Finally, the phosphocholine group is transferred from CDP-choline to a diacylglycerol molecule, resulting in the formation of phosphatidylcholine,

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130. (A) Both A and R are true and R is the correct explanation of A.
The urea cycle and the citric acid cycle are closely integrated through the aspartate-argininosuccinate shunt. Fumarate produced in the cytosol by the urea cycle can be converted to malate by cytosolic fumarase. This malate then enters the mitochondria, where it is oxidized to oxaloacetate, effectively regenerating the aspartate needed for the urea cycle and contributing to the TCA cycle.

131. (C) Arginase
Arginase is the enzyme that catalyzes the final hydrolytic step of the urea cycle. It cleaves the guanidino group of arginine to produce one molecule of urea and one molecule of ornithine. While urea is released into the blood for excretion, ornithine is transported back into the mitochondria to initiate another round of the cycle by reacting with carbamoyl phosphate.

132. (A) Carbon dioxide (as bicarbonate)
The single carbon atom found in the urea molecule is derived from bicarbonate, which is formed from carbon dioxide in the body. This carbon is incorporated during the first step of the urea cycle, where carbamoyl phosphate synthetase 1 combines ammonia and bicarbonate. This process effectively removes waste carbon dioxide while also facilitating the detoxification of nitrogenous waste.

133. (D) They can be synthesized endogenously by the organism
Non-essential amino acids are a group of amino acids that do not need to be provided in the diet because the organism has the metabolic pathways necessary to synthesize them endogenously. These are typically formed from common metabolic intermediates found in glycolysis or the citric acid cycle. However, they are still absolutely required for protein synthesis and other cellular functions.

134. (B) 3-Phosphoglycerate
The biosynthesis of serine begins with the glycolytic intermediate 3-phosphoglycerate. In a three-step pathway, 3-phosphoglycerate is first oxidized to 3-phosphopyruvate, then transaminated to 3-phosphoserine, and finally dephosphorylated to yield free serine. Serine then serves as a precursor for other important molecules, including glycine and cysteine, and is a vital component of many proteins and phospholipids in the cell.

135. (C) Pyruvate
Alanine is synthesized in the cell through a single-step transamination reaction. The enzyme alanine aminotransferase catalyzes the transfer of an alpha-amino group from glutamate to the alpha-keto acid pyruvate. This reversible reaction is central to the glucose-alanine cycle and allows for the easy interconversion between carbohydrate and amino acid metabolism depending on the energy needs of the organism.

136. (D) Oxaloacetate
Aspartate is formed via a transamination reaction from the citric acid cycle intermediate oxaloacetate. The enzyme aspartate aminotransferase facilitates the transfer of an amino group, typically from glutamate, to oxaloacetate. This process is essential not only for protein synthesis but also for the urea cycle and the malate-aspartate shuttle, which moves reducing equivalents across the mitochondrial membrane.

137. (A) Asparagine
Asparagine is synthesized by the amidation of its parent amino acid, aspartate. This reaction is catalyzed by the enzyme asparagine synthetase and requires glutamine as the amino group donor and the hydrolysis of ATP to AMP and pyrophosphate. This process ensures that the cell has a sufficient supply of asparagine for protein construction, particularly in tissues with high turnover.

138. (B) Glutamate
Proline is a cyclic amino acid synthesized through a multi-step pathway starting from glutamate. Glutamate is first converted into glutamate-gamma-semialdehyde, which then spontaneously cyclizes to form a pyrroline intermediate. Finally, this intermediate is reduced to produce proline. This pathway is important for the synthesis of collagen, where proline and its derivative hydroxyproline are major structural components.

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139. (B) Tetrahydrofolate
The interconversion of serine and glycine is catalyzed by the enzyme serine hydroxymethyltransferase. This reaction involves the transfer of a one-carbon unit from serine to the coenzyme tetrahydrofolate, resulting in the

two carbon atoms, identified as carbon-4 and carbon-5, and one nitrogen atom, identified as nitrogen-7. This step occurs early in the biosynthetic pathway and is essential for building the foundational bicyclic structure of the purine base.

159. (C) IMP (Inosine monophosphate)
Inosine monophosphate is the first nucleotide with a complete purine ring to be synthesized in the de novo pathway. It contains the base hypoxanthine linked to a ribose phosphate. IMP serves as a common branch point, from which it can be subsequently converted into either adenosine monophosphate or guanosine monophosphate to meet the specific needs of the cell.

160. (D) I, II, III and IV
Pyrimidine biosynthesis differs from purines as the ring is fully assembled before being attached to PRPP. The regulatory enzyme is carbamoyl phosphate synthetase II, which is located in the cytosol. Uridine monophosphate is formed by the decarboxylation of orotidylate. All these statements are correct, describing the fundamental biochemical characteristics of the pyrimidine pathway in mammalian cells.

161. (D) Glutamine, Aspartate, and CO_2
The pyrimidine ring is a relatively simple six-membered structure. Its atoms are derived from three main sources: the amino acid aspartate, which provides three carbons and one nitrogen; glutamine, which provides the second nitrogen; and carbon dioxide, which provides the final carbon. These components are combined to form the orotate intermediate, which is then attached to a ribose unit.

162. (A) Thioredoxin
Ribonucleotide reductase is the enzyme responsible for the production of deoxyribonucleotides from ribonucleotides, a critical step for DNA synthesis. To reduce the ribose sugar, the enzyme requires a source of electrons. This is provided by thioredoxin, a small protein with essential sulfhydryl groups that undergo redox cycling. Thioredoxin is itself kept in a reduced state by thioredoxin reductase using NADPH.

163. (C) N5,$N_1$0-methylene-tetrahydrofolate
The synthesis of deoxythymidine monophosphate from deoxyuridine monophosphate is catalyzed by thymidylate synthase. This reaction requires N5,$N_1$0-methylene-tetrahydrofolate as both a one-carbon donor and a reducing agent. During the reaction, the folate cofactor is oxidized to dihydrofolate. This step is a major target for several chemotherapeutic drugs because it is essential for the production of the thymine needed for DNA replication.

164. (A) Hypoxanthine to IMP and Guanine to GMP
The salvage pathway for purines is an energy-efficient mechanism that recycles free bases into nucleotides. The enzyme hypoxanthine-guanine phosphoribosyltransferase is central to this process. It catalyzes the transfer of a phosphoribosyl group from PRPP to either hypoxanthine, forming inosine monophosphate, or guanine, forming guanosine monophosphate. This prevents the degradation of these bases and reduces the need for de novo synthesis.

165. (D) Uric acid
In humans and higher primates, the catabolic pathway for purine nucleotides concludes with the formation of uric acid. This is because these species lack the enzyme urate oxidase, which in other mammals further degrades uric acid into more soluble compounds. Uric acid is relatively insoluble and is excreted primarily by the kidneys, where its accumulation can lead to clinical conditions.

166. (B) Allantoin
In most non-primate mammals, the enzyme urate oxidase, or uricase, is present in the liver. This enzyme catalyzes the oxidation of uric acid into allantoin, a much more water-soluble nitrogenous compound. This conversion allows for the easy and safe excretion of purine degradation products in the urine, preventing the complications associated with high levels of insoluble uric acid crystals.

167. (C) Xanthine oxidase
Xanthine oxidase is a complex metalloenzyme that catalyzes the final two steps of purine catabolism. It first oxidizes hypoxanthine to xanthine and then further oxidizes xanthine to produce uric acid. During these reactions, the enzyme also generates reactive oxygen species, such as superoxide and hydrogen peroxide. This enzyme is a major clinical target for the treatment of hyperuricemia and gout.

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149. (D) Glycine
The biosynthesis of porphyrins, including heme, begins in the mitochondria with the condensation of succinyl-coenzyme A and the amino acid glycine. This reaction is catalyzed by the enzyme delta-aminolevulinate synthase and requires pyridoxal phosphate. This is the rate-limiting step of the entire heme biosynthetic pathway, which is essential for the production of hemoglobin, myoglobin, and various cytochromes in the body.

150. (A) I, II and III
Nitric oxide is a potent signaling molecule synthesized by a family of enzymes called nitric oxide synthases. These enzymes use the amino acid arginine as a substrate and require molecular oxygen and NADPH. During the reaction, nitric oxide is produced along with the amino acid citrulline as a byproduct. Therefore, all three statements regarding its synthesis are correct and factually accurate.

151. (C) Glycine, Arginine, Methionine
Creatine is synthesized through a pathway involving three different amino acids. First, glycine and arginine combine to form guanidinoacetate in the kidneys. This intermediate is then transported to the liver, where it is methylated by S-adenosylmethionine, derived from methionine, to produce creatine. Creatine is then released into the blood and taken up by tissues with high energy demands like muscle.

152. (D) Serotonin
Melatonin is a hormone produced by the pineal gland that is essential for regulating the sleep-wake cycle and circadian rhythms. It is synthesized from the neurotransmitter serotonin through a two-step process involving acetylation and then methylation. Since serotonin is itself derived from tryptophan, the production of melatonin is ultimately dependent on the availability of this essential amino acid.

153. (A) Tyrosine residues within the protein thyroglobulin
Thyroid hormones, thyroxine and triiodothyronine, are synthesized in the thyroid gland through the iodination and coupling of specific tyrosine residues within a large precursor protein called thyroglobulin. This process occurs in the follicular lumen. Once synthesized, the hormones remain part of the thyroglobulin protein until they are released into the bloodstream following the proteolytic breakdown of the protein.

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154. (B) Tryptophan
Although most nicotinamide adenine dinucleotide is obtained from the diet as niacin, the body can also synthesize it de novo using the essential amino acid tryptophan. This complex biosynthetic pathway involves multiple steps and is particularly important when dietary niacin is low. A deficiency in either niacin or tryptophan can lead to pellagra, a disease characterized by dermatitis and dementia.

155. (B) Tyrosine → DOPA → Dopamine → Norepinephrine → Epinephrine
The biosynthetic pathway for epinephrine follows a strict sequential order. It begins with the hydroxylation of tyrosine to form DOPA. DOPA is then decarboxylated to produce dopamine. Dopamine is hydroxylated to form norepinephrine, which is finally methylated to yield epinephrine. This pathway is essential for the body's acute stress response and is primarily localized in the adrenal medulla.

156. (A) Glutamine
The first committed step of de novo purine biosynthesis is the displacement of the pyrophosphate group from PRPP by an amino group to form 5-phosphoribosyl-1-amine. This reaction is catalyzed by the enzyme glutamine-PRPP amidotransferase. Glutamine serves as the essential nitrogen donor for this step, and the enzyme is a major site of feedback regulation by the pathway's end products.

157. (C) Ribose-5-phosphate
5-Phosphoribosyl-1-pyrophosphate is a critical activated intermediate for the synthesis of both purine and pyrimidine nucleotides, as well as the salvage pathways. It is synthesized directly from ribose-5-phosphate and ATP in a reaction catalyzed by the enzyme PRPP synthetase. Ribose-5-phosphate itself is primarily generated through the pentose phosphate pathway, linking carbohydrate metabolism to the production of nucleic acid precursors.

158. (D) C_4, C_5, and N_7
During the de novo synthesis of the purine ring, the entire glycine molecule is incorporated into the structure. Specifically, glycine provides

formation of glycine and N5,$N_1$0-methylene-tetrahydrofolate. This pathway is a major source of one-carbon units for the biosynthesis of various compounds, including purines and the methyl group of thymidylate.

140. (A) P-2, Q-1, R-4, S-3
Many non-essential amino acids are synthesized directly from intermediates of central metabolism. Alanine is derived from pyruvate, and glutamate is formed from alpha-ketoglutarate. Serine is synthesized from the glycolytic intermediate 3-phosphoglycerate, while aspartate is produced from the citric acid cycle intermediate oxaloacetate. These transamination and biosynthetic pathways ensure the cell maintains a balanced pool of amino acids.

141. (C) Phenylalanine
Tyrosine is classified as a non-essential amino acid because it can be synthesized endogenously by the hydroxylation of the essential amino acid phenylalanine. This reaction is catalyzed by phenylalanine hydroxylase. However, if the dietary intake of phenylalanine is insufficient, tyrosine must then be provided in the diet, making it a conditionally essential amino acid under those specific circumstances.

142. (D) Methionine
The synthesis of cysteine is a complex process that involves two different amino acids. The carbon skeleton and the amino group are provided by serine, while the sulfur atom is derived from the essential amino acid methionine through the intermediate homocysteine. This pathway, known as the transsulfuration pathway, is critical for the production of glutathione and other sulfur-containing compounds.

143. (C) Leucine
Among the twenty standard amino acids, leucine and lysine are the only two that are strictly ketogenic, meaning their catabolism yields only acetyl-coenzyme A or acetoacetate. Since leucine cannot be synthesized by the human body and must be obtained from the diet, it is classified as both an essential and a strictly ketogenic amino acid.

144. (B) Tyrosine
The catecholamines, which include the neurotransmitters dopamine, norepinephrine, and epinephrine, are a group of signaling molecules synthesized from the amino acid tyrosine. This biosynthetic pathway primarily occurs in the adrenal medulla and specific neurons in the brain. Tyrosine is first hydroxylated and then undergoes a series of decarboxylation, hydroxylation, and methylation reactions to produce the various active catecholamines.

145. (D) Tyrosine hydroxylase
Tyrosine hydroxylase is the enzyme that catalyzes the initial and rate-limiting step in the biosynthesis of catecholamines. It converts tyrosine into L-DOPA using molecular oxygen and the cofactor tetrahydrobiopterin. Because this step determines the overall rate of production for dopamine, norepinephrine, and epinephrine, the activity of tyrosine hydroxylase is tightly regulated by feedback inhibition and various signaling pathways.

146. (A) Tryptophan
Serotonin, an important neurotransmitter involved in regulating mood, sleep, and appetite, is synthesized from the essential amino acid tryptophan. The pathway involves two steps: the hydroxylation of tryptophan to 5-hydroxytryptophan, followed by decarboxylation to form serotonin. This process occurs in the pineal gland, the brainstem, and specialized cells in the gastrointestinal tract, where most serotonin is located.

147. (C) Pyridoxal phosphate (PLP)
Histamine is a biogenic amine produced by the decarboxylation of the amino acid histidine. This reaction is catalyzed by the enzyme histidine decarboxylase. Like most amino acid decarboxylases, this enzyme requires pyridoxal phosphate as an essential coenzyme. Histamine plays a major role in the inflammatory response, gastric acid secretion, and functions as a neurotransmitter in the central nervous system.

148. (A) Glutamate
Gamma-aminobutyric acid is the primary inhibitory neurotransmitter in the mammalian central nervous system. It is synthesized through the direct decarboxylation of the excitatory amino acid glutamate. This reaction is catalyzed by the enzyme glutamate decarboxylase, which requires pyridoxal phosphate as a cofactor. This single metabolic step is critical for maintaining the proper balance between neuronal excitation and inhibition.

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168. (D) Xanthine oxidase
Allopurinol is a structural isomer of hypoxanthine and is used medically to treat conditions associated with high uric acid levels. It acts as a potent suicide inhibitor of xanthine oxidase. By blocking this enzyme, allopurinol prevents the conversion of hypoxanthine and xanthine into uric acid, leading to an increase in these more soluble precursors that are easily excreted.

169. (A) Direct conversion to Acetyl-CoA
Glucose-6-phosphate is a central metabolite that can enter several different pathways. It can be isomerized to fructose-6-phosphate for glycolysis, converted to glucose-1-phosphate for glycogen synthesis, or oxidized in the pentose phosphate pathway. However, there is no single enzymatic step that directly converts glucose-6-phosphate into acetyl-coenzyme A; it must first undergo the entire glycolytic sequence to become pyruvate.

170. (A) I, II, III, IV
Pyruvate is a versatile intermediate in cellular metabolism. It can be reduced to lactate during anaerobic conditions, transaminated to form alanine, carboxylated to oxaloacetate for gluconeogenesis, or oxidatively decarboxylated to acetyl-coenzyme A to enter the citric acid cycle. Statement V is incorrect as pyruvate is not directly converted to acetoacetate, which is a ketone body formed from acetyl-CoA.

171. (B) Glucose
Acetyl-coenzyme A is a fundamental building block in lipid metabolism, serving as the precursor for fatty acids, cholesterol, and ketone bodies. However, in animals, it cannot be used for the net synthesis of glucose. This is because the pyruvate dehydrogenase reaction is irreversible and both carbons entering the citric acid cycle as acetyl-CoA are lost as carbon dioxide.

172. (A) Hepatic glycogenolysis
During the first several hours of a fast, the body primarily maintains blood glucose levels through the breakdown of glycogen stored in the liver. This process, known as hepatic glycogenolysis, rapidly releases free glucose into the circulation. While gluconeogenesis also begins to ramp up during this time, it does not become the dominant source of blood glucose until several hours later.

173. (C) Ketone bodies
Under normal conditions, the brain relies almost exclusively on glucose for its energy needs. However, during prolonged fasting or starvation, blood glucose levels drop and the liver begins to produce large quantities of ketone bodies from fatty acids. The brain adapts by inducing enzymes that allow it to utilize acetoacetate and beta-hydroxybutyrate as significant alternative fuels, reducing the need for glucose.

174. (D) Kidneys (renal cortex)
In the initial stages of fasting, the liver is the primary site of gluconeogenesis. However, as starvation becomes prolonged, the kidneys, specifically the renal cortex, significantly increase their gluconeogenic capacity. In very long-term starvation, the kidneys can contribute up to half of the total glucose produced, while also helping to maintain acid-base balance by utilizing glutamine and excreting ammonium.

175. (C) Insulin
Insulin is the dominant anabolic hormone that regulates metabolism in the well-fed state. Secreted by the pancreas in response to high blood glucose, it promotes the uptake of glucose by tissues, stimulates the synthesis of glycogen in the liver and muscle, and activates de novo fatty acid synthesis in adipose tissue, while simultaneously inhibiting pathways like gluconeogenesis and lipolysis.

176. (B) Reliance on fatty acids as the primary energy source
In a fasting state, the metabolic profile of resting skeletal muscle shifts to conserve glucose for the brain. Under the influence of low insulin and higher glucagon or epinephrine, the muscle decreases its glucose uptake and switches to utilizing free fatty acids as its primary energy source. These fatty acids are mobilized from adipose tissue and oxidized via mitochondrial beta-oxidation.

177. (D) It synthesizes it from dihydroxyacetone phosphate (DHAP) produced during glycolysis
Adipose tissue requires glycerol-3-phosphate to esterify free fatty acids into triacylglycerols for storage. Because it lacks the enzyme glycerol kinase, it cannot recycle free glycerol. Instead, it must derive glycerol-3-phosphate from dihydroxyacetone phosphate, an intermediate of glycolysis. This requirement ensures that fat

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storage in adipocytes only occurs when there is a sufficient supply of glucose entering the tissue.

178. (A) Mitochondria
Mature red blood cells lack all intracellular organelles, including a nucleus and mitochondria. Without mitochondria, they are incapable of performing the citric acid cycle or oxidative phosphorylation. Consequently, erythrocytes rely entirely on anaerobic glycolysis in the cytosol for their ATP production. This metabolic strategy also ensures that the oxygen they transport is not consumed by their own internal processes.

179. (C) Glucose and Lactate
The Cori cycle describes a metabolic partnership between skeletal muscle and the liver. During intense exercise, muscles produce lactate from glucose via anaerobic glycolysis. This lactate is released into the blood and taken up by the liver. In the liver, lactate is converted back into glucose via gluconeogenesis, which is then returned through the bloodstream to the muscle.

180. (A) AMP
During intense physical exertion, the rapid consumption of ATP leads to a significant increase in the concentration of adenosine monophosphate within the muscle cell. AMP acts as a potent allosteric activator of glycogen phosphorylase b, the less active form of the enzyme. This activation allows for the immediate mobilization of glycogen to provide energy even before hormonal signals arrive.

181. (D) Glucose-6-phosphatase
Von Gierke's disease, or type I glycogen storage disease, is a metabolic disorder caused by a deficiency in the enzyme glucose-6-phosphatase. This enzyme is essential for the final step of both glycogenolysis and gluconeogenesis in the liver. Its absence prevents the liver from releasing free glucose into the blood, leading to severe fasting hypoglycemia and an accumulation of glycogen.

182. (B) Muscle weakness and cramping during exercise
Von Gierke's disease primarily affects the liver and kidneys, where glucose-6-phosphatase is expressed. Clinical signs include severe hypoglycemia, hepatomegaly due to glycogen accumulation, and hyperuricemia. Muscle weakness and cramping during exercise are not typical of this condition because muscle tissue does not normally express this enzyme and relies on its own glycogen stores, which are mobilizable in these patients.

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183. (C) Lysosomes
Pompe disease is unique among glycogen storage diseases because it is also classified as a lysosomal storage disorder. It is caused by a deficiency in the lysosomal enzyme alpha-1,4-glucosidase, which is responsible for breaking down glycogen that has been engulfed by lysosomes. The resulting accumulation of glycogen within lysosomes leads to progressive muscle damage and severe cardiomyopathy.

184. (D) Insulin deficiency and glucagon excess driving lipolysis and ketogenesis
Diabetic ketoacidosis is a life-threatening complication typically seen in type 1 diabetes. It is fundamentally driven by an absolute deficiency of insulin coupled with an excess of glucagon. This hormonal imbalance leads to unrestrained lipolysis in adipose tissue and accelerated beta-oxidation in the liver. The resulting overproduction of ketone bodies exceeds the body's buffering capacity, leading to severe metabolic acidosis.

185. (A) Decreased activity of lipoprotein lipase (LPL) due to lack of insulin
In untreated type 1 diabetes, hypertriglyceridemia frequently occurs due to the lack of insulin. Insulin is a critical activator of the enzyme lipoprotein lipase, which is responsible for clearing triacylglycerols from chylomicrons and VLDLs in the blood. When insulin is absent, lipoprotein lipase activity is significantly reduced, leading to an accumulation of these triglyceride-rich lipoproteins in the general circulation.

186. (B) Inability to synthesize VLDL fast enough to export hepatic lipid influx
Fatty liver syndrome in high-yielding dairy cows develops when the rate of fatty acid mobilization from adipose tissue exceeds the liver's capacity to process them. While the liver can oxidize some fatty acids or convert them into ketones, the excess is esterified into triacylglycerols. Because ruminant livers are relatively inefficient at synthesizing and exporting VLDLs, these lipids accumulate.

187. (B) The LDL receptor
Familial hypercholesterolemia is a genetic disorder most commonly caused by mutations in the gene for the low-density lipoprotein receptor. This receptor is essential for the removal of LDL particles from the blood via receptor-mediated endocytosis. A defect in this process leads to dangerously high levels of circulating cholesterol, which significantly increases the risk of early-onset atherosclerosis and cardiovascular disease.

188. (A) Potassium (initially)
During diabetic ketoacidosis, several biochemical markers are altered. While blood glucose and ketones are markedly elevated, plasma potassium levels are also characteristically high initially. This hyperkalemia occurs because protons entering the cells during acidosis are exchanged for potassium ions, and because the lack of insulin prevents potassium from being taken up by the cells, despite an overall total body deficit.

189. (C) McArdle's disease
McArdle's disease, or type V glycogen storage disease, is caused by a genetic deficiency in the muscle-specific isoform of glycogen phosphorylase. This defect prevents the mobilization of muscle glycogen during exercise, leading to symptoms like premature fatigue, muscle pain, and cramping. A hallmark of the condition is the failure of blood lactate levels to rise during an ischemic exercise test.

190. (A) Both A and R are true and R is the correct explanation of A.
In diabetic ketoacidosis, the accumulation of ketone bodies leads to a significant decrease in blood pH. To compensate for this metabolic acidosis, the body activates the respiratory center to increase the depth and frequency of breathing. These Kussmaul respirations help lower the partial pressure of carbon dioxide in the blood, thereby raising the pH back toward the physiological range.

191. (C) Depletion of brain alpha-ketoglutarate via synthesis of glutamate and glutamine
The neurotoxicity of ammonia is thought to result from its effect on glutamate metabolism in the brain. High levels of ammonia drive the synthesis of glutamate and glutamine, which consumes alpha-ketoglutarate, a key intermediate of the citric acid cycle. This depletion of alpha-ketoglutarate impairs mitochondrial energy production in neurons, leading to cellular dysfunction, cerebral edema, and severe neurological symptoms.

192. (B) Orotic acid
Ornithine transcarbamylase deficiency is the most common urea cycle disorder. When this mitochondrial enzyme is missing, its substrate, carbamoyl phosphate, accumulates and leaks into the cytosol. There, it enters the pyrimidine biosynthetic pathway, leading to an overproduction and increased urinary excretion of orotic acid. This biochemical finding is a critical diagnostic marker that distinguishes OTC deficiency from other hyperammonemic conditions.

193. (D) Excessive production or reduced renal excretion of insoluble urate crystals
Gout is a clinical condition characterized by recurrent episodes of acute inflammatory arthritis. It is caused by chronic hyperuricemia, which leads to the deposition of monosodium urate crystals in the joints and surrounding tissues. This can result from either the overproduction of uric acid due to metabolic defects or, more commonly, the reduced renal excretion of uric acid by the kidneys.

194. (A) Hypoxanthine-guanine phosphoribosyltransferase (HGPRT)
Lesch-Nyhan syndrome is a devastating genetic disorder caused by a near-complete deficiency of the purine salvage enzyme hypoxanthine-guanine phosphoribosyltransferase. This defect leads to the accumulation of PRPP and the failure to recycle purine bases. Consequently, there is a massive increase in de novo purine synthesis and subsequent degradation, resulting in severe hyperuricemia, neurological impairment, and characteristic self-injurious behavior.

195. (C) Increased PRPP levels driving purine synthesis coupled with salvage loss
The deficiency of HGPRT leads to high uric acid levels through two coordinated mechanisms. First, the failure to salvage hypoxanthine and guanine means these bases are instead degraded to uric acid. Second, the lack of salvage increases the intracellular concentration of PRPP, which is a potent activator of the de novo purine synthesis pathway, leading to an overproduction of purines.

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214. (C) It acts as an RNA-guided endonuclease to create targeted double-strand breaks
In the CRISPR-Cas9 system, the Cas9 protein functions as a specialized RNA-guided endonuclease. Its role is to scan the genome and create a precise double-strand break at a specific DNA sequence targeted by a complementary guide RNA. Once the DNA is cut, the cell's natural repair mechanisms are activated, which can be utilized to either disrupt or correct the gene.

215. (C) The single guide RNA (sgRNA) sequence
The specificity of the CRISPR-Cas9 system is determined by the single guide RNA molecule. This synthetic RNA contains a twenty-nucleotide sequence that is complementary to the target DNA site. By changing this sequence, researchers can redirect the Cas9 enzyme to cleave almost any location in the genome, provided a suitable protospacer adjacent motif is present nearby, making it highly versatile.

216. (A) Non-homologous end joining (NHEJ)
Non-homologous end joining is the primary pathway used by eukaryotic cells to repair double-strand breaks in DNA. It involves the direct ligation of the broken ends without a template. Because this process is inherently error-prone, it frequently results in small insertions or deletions at the site of repair. These indels can cause frameshift mutations, effectively creating a gene knockout.

217. (B) Homology-directed repair (HDR)
To achieve precise correction of a pathogenic mutation, researchers rely on the homology-directed repair pathway. This mechanism uses a homologous DNA template to repair the double-strand break accurately. By providing an exogenous donor DNA template containing the desired corrected sequence, the cell's repair machinery can be directed to incorporate the specific changes, allowing for the perfect correction of the genome.

218. (B) Protospacer Adjacent Motif (PAM)
The protospacer adjacent motif is a short, specific DNA sequence located immediately following the target site recognized by the CRISPR-Cas9 system. The Cas9 protein must first identify and bind to the PAM before it can unwind the DNA and check for complementarity with its guide RNA. Different Cas enzymes recognize different PAM sequences, which is a critical consideration in targeting.

219. (A) Retinal dystrophy causing blindness
Luxturna is a landmark gene therapy approved for the treatment of Leber congenital amaurosis, a rare inherited retinal dystrophy that causes progressive blindness. It uses an adeno-associated virus vector to deliver a functional copy of the RPE65 gene directly to the retinal cells. This allows the cells to produce the essential enzyme needed for the visual cycle, restoring vision.

220. (A) Both A and R are true and R is the correct explanation of A.
Standard retroviral vectors are generally restricted to infecting dividing cells. This is because the viral pre-integration complex is too large to pass through the nuclear pore and can only access the host genome when the nuclear envelope breaks down during mitosis. Consequently, they are ineffective for delivering genes to post-mitotic cells like mature neurons, as stated in the assertion.

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221. (D) They can infect and integrate into both dividing and non-dividing cells
Lentiviruses, such as HIV-1, are a subclass of retroviruses that have evolved the ability to actively transport their genetic material across the intact nuclear envelope. This unique feature allows lentiviral vectors to infect and integrate into both dividing and non-dividing cells, including neurons and hepatocytes. This makes them a highly versatile and powerful tool for many different gene therapy applications.

222. (C) High hepatotropism
Many metabolic disorders, such as phenylketonuria or urea cycle defects, originate from enzyme deficiencies in the liver. For an in vivo gene therapy to be effective, the delivery vector must have a high degree of hepatotropism, meaning it must selectively and efficiently target and transduce hepatocytes. This ensures the therapeutic gene is expressed in the correct tissue for metabolism.

223. (B) Inactive Cas9-deaminase fusions that alter bases without double-strand breaks
Base editing is an advanced variation of CRISPR technology that allows for the direct, permanent conversion of one DNA base pair into another without creating a double-strand break. This

205. (D) Alpha-keto acids derived from leucine, isoleucine, and valine
In patients with maple syrup urine disease, the deficiency of the dehydrogenase complex results in the accumulation of the three branched-chain amino acids and their corresponding alpha-keto acids in the blood and urine. These keto acids, particularly the one derived from isoleucine, are responsible for the distinctive maple syrup-like odor. The accumulation of these metabolites is highly toxic and requires intervention.

206. (C) Tetrahydrobiopterin (BH4)
A variant form of phenylketonuria can occur even when the phenylalanine hydroxylase enzyme itself is normal. This condition is caused by a deficiency in the synthesis or recycling of tetrahydrobiopterin, which is an essential cofactor for the enzyme. Since BH4 is also required for the synthesis of neurotransmitters like dopamine and serotonin, this form of the disease is typically more severe.

207. (B) Ochronosis and severe early-onset arthritis
While alkaptonuria is relatively asymptomatic in childhood, the chronic accumulation of homogentisic acid eventually leads to significant health problems in adulthood. The acid and its oxidation products bind to collagen in cartilage and other connective tissues, causing a blue-black pigmentation known as ochronosis. This process leads to the early onset of severe, debilitating arthritis, particularly in the large joints.

208. (D) A diet severely restricted in phenylalanine but supplemented with tyrosine
The management of classical phenylketonuria requires a lifelong dietary intervention started immediately after birth. The diet must be severely restricted in phenylalanine to prevent its accumulation, but it must also be supplemented with tyrosine, which becomes an essential amino acid in these patients. This specialized diet is carefully balanced to provide enough phenylalanine for protein synthesis while avoiding neurotoxicity.

209. (A) Introducing functional genetic material into targeted non-reproductive cells of an individual
Somatic gene therapy is a medical approach that involves the introduction of functional genetic material into the non-reproductive cells of a patient to treat a disease. Unlike germline therapy, the genetic changes made in somatic cells are not passed on to future generations. This technique is used to treat various conditions, including genetic disorders, cancers, and certain infectious diseases.

210. (A) Cell isolation → Transduction with vector → Culture and expansion → Reinfusion into patient
Ex vivo gene therapy involves several controlled steps performed outside the patient's body. First, target cells, such as hematopoietic stem cells, are isolated from the patient. These cells are then transduced with a viral vector carrying the therapeutic gene. After a period of culture and expansion to ensure successful integration and expression, the modified cells are reinfused back into the patient.

211. (A) Retrovirus
Retroviruses are a class of viral vectors that have the unique ability to integrate their genetic material directly into the host cell's genome. This integration ensures that the therapeutic gene is passed on to all daughter cells, providing stable and long-term expression. However, the random nature of this integration carries a risk of insertional mutagenesis, which can potentially disrupt host genes.

212. (D) They evoke minimal immune responses and typically remain episomal
Adeno-associated viruses are widely used in gene therapy due to several favorable characteristics. They are non-pathogenic and generally evoke a very minimal immune response in the host. Most importantly, AAVs typically remain as episomes within the nucleus rather than integrating into the host genome, which significantly reduces the risk of causing cancer through insertional mutagenesis while still providing expression.

213. (B) Lower immunogenicity and capacity to package larger nucleic acid constructs
Non-viral delivery systems, such as lipid nanoparticles, offer several advantages over traditional viral vectors. They generally have much lower immunogenicity, allowing for repeated administrations without triggering a strong immune response. Additionally, they are not limited by the rigid structural constraints of a viral capsid, giving them a much larger capacity to package and deliver large or multiple nucleic acid constructs.

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196. (A) Adenosine deaminase (ADA)
Severe Combined Immunodeficiency can be caused by a genetic defect in adenosine deaminase, an enzyme required for the catabolism of purines. ADA converts adenosine and deoxyadenosine into inosine and deoxyinosine. Its deficiency leads to the buildup of toxic metabolites that specifically target and destroy developing T and B lymphocytes, leaving the individual extremely vulnerable to infections from a very young age.

197. (D) Conversion to dATP which inhibits ribonucleotide reductase and DNA synthesis
In adenosine deaminase deficiency, the accumulation of deoxyadenosine leads to its phosphorylation into dATP. High levels of dATP act as a potent allosteric inhibitor of ribonucleotide reductase, the enzyme responsible for producing all four deoxyribonucleotides. This inhibition halts DNA synthesis and cell division, which is particularly devastating for the rapidly proliferating cells of the immune system, such as lymphocytes.

198. (B) There is currently no cure for the neurological symptoms
While the hyperuricemia in Lesch-Nyhan syndrome can be managed with drugs like allopurinol to prevent gout and kidney stones, there is currently no effective treatment or cure for the severe neurological and behavioral symptoms. The complex relationship between the purine salvage defect and the dysfunction of the brain's dopamine system remains poorly understood, making these symptoms extremely difficult to treat.

199. (C) Phenylalanine hydroxylase
Classical phenylketonuria is an autosomal recessive disorder caused by a deficiency in the hepatic enzyme phenylalanine hydroxylase. This enzyme is responsible for converting the essential amino acid phenylalanine into tyrosine. When it is defective, phenylalanine accumulates to high levels in the blood and tissues, leading to the production of toxic metabolites and causing progressive and irreversible damage to the developing brain.

200. (A) P-3, Q-4, R-1, S-2
Inborn errors of metabolism result from specific enzyme deficiencies. Alkaptonuria is caused by a lack of homogentisate dioxygenase. Maple syrup urine disease involves a defect in the branched-chain alpha-keto acid dehydrogenase complex. Albinism results from a deficiency in tyrosinase, and phenylketonuria is caused by a lack of phenylalanine hydroxylase. Each condition leads to the accumulation of specific toxic intermediates.

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201. (B) Accumulated phenylalanine inhibiting transport of large neutral amino acids
The primary mechanism of brain damage in untreated phenylketonuria is related to the extremely high levels of phenylalanine in the blood. Phenylalanine competes with other large neutral amino acids for transport across the blood-brain barrier via the same carrier protein. This competition leads to a deficiency of other essential amino acids in the brain, impairing the synthesis of neurotransmitters and proteins.

202. (B) Alkaptonuria
Alkaptonuria is characterized by a deficiency in homogentisate oxidase, leading to the accumulation of homogentisic acid. When urine containing this acid is exposed to air, the acid is oxidized and polymerized into a dark, melanin-like pigment. This distinctive darkening of the urine upon standing is a pathognomonic sign of the disease, which also eventually leads to connective tissue pigmentation and arthritis.

203. (A) Tyrosinase
Oculocutaneous albinism type 1 is caused by a genetic mutation in the tyrosinase gene. Tyrosinase is the copper-containing enzyme responsible for the first two steps of melanin synthesis from tyrosine. A deficiency in this enzyme prevents the production of melanin pigment in the skin, hair, and eyes, resulting in the characteristic white appearance and increased sensitivity to ultraviolet radiation and visual defects.

204. (C) Branched-chain amino acids
Maple syrup urine disease is a metabolic disorder caused by a defect in the branched-chain alpha-keto acid dehydrogenase complex. This enzyme is essential for the catabolism of the three branched-chain amino acids: leucine, isoleucine, and valine. The inability to break down these amino acids leads to their accumulation and the characteristic sweet odor of the urine, along with severe neurotoxicity.

is achieved by fusing a catalytically inactive or nickase version of Cas9 to a deaminase enzyme. This approach significantly reduces the risk of unintended insertions or deletions associated with standard CRISPR.

224. (D) SCID (Severe Combined Immunodeficiency)
Severe Combined Immunodeficiency due to adenosine deaminase deficiency has been a primary target for gene therapy since the early 1990s. Modern protocols typically use lentiviral vectors to modify the patient's own hematopoietic stem cells ex vivo. These modified cells are then reinfused, where they differentiate into functional immune cells, providing a potentially curative treatment for this otherwise fatal disorder.

225. (A) The absolute temperature and the concentrations of reactants and products
The change in Gibbs free energy for a chemical reaction in a biological system is not a constant value but depends on several variables. Specifically, it is determined by the absolute temperature and the actual concentrations of the reactants and products present in the cell. This explains why reactions can proceed in different directions depending on the metabolic state of the organism.

226. (C) At equilibrium
When the change in Gibbs free energy for a reaction is exactly zero, the system has reached a state of chemical equilibrium. At this point, there is no net driving force for the reaction to proceed in either the forward or the reverse direction, and the rates of the two processes are equal. This represents a state of stability.

227. (A) The formation of a common intermediate
The mechanism of energy coupling in biological systems often involves the formation of a common chemical intermediate. By sharing a shared molecule, two reactions can be physically and thermodynamically linked. This allows the energy released from a highly exergonic reaction, such as the hydrolysis of ATP, to be directly captured and used to power an otherwise unfavorable endergonic reaction.

228. (D) The affinity of a molecule for electrons
The standard reduction potential of a molecule is a quantitative measure of its chemical affinity for electrons. It indicates the likelihood that a species will be reduced by accepting electrons. Molecules with a high positive potential have a strong affinity for electrons and act as oxidizing agents, while those with a negative potential tend to donate electrons and act as reducers.

229. (B) Negative standard free energy change, indicating a spontaneous reaction
In redox chemistry, there is a fundamental relationship between the change in reduction potential and the change in free energy. A positive overall change in the standard reduction potential for a redox reaction corresponds to a negative change in the standard free energy. This relationship signifies that the transfer of electrons is thermodynamically favorable and will occur spontaneously in the system.

230. (A) I, III, II, IV
In the mitochondrial electron transport chain, electrons flow from carriers with lower reduction potentials to those with higher potentials. NAD+ has the most negative potential, followed by FAD, then cytochrome c, and finally molecular oxygen, which has the most positive potential. This sequential arrangement ensures that each step of the transfer is exergonic, allowing for the generation of energy.

231. (D) Group transfer potential
The transfer of a phosphoryl group from adenosine triphosphate to glucose to form glucose-6-phosphate is a classic example of group transfer potential. Because ATP has a high phosphoryl transfer potential, it can easily donate its terminal phosphate to various acceptors. This process is catalyzed by enzymes and is often the first step in metabolic pathways, serving to activate the substrate.

232. (A) ATP acts as an intermediate carrier of phosphoryl groups linking catabolism and anabolism
The ATP-ADP cycle is the fundamental mechanism for energy exchange in all living cells. Adenosine triphosphate acts as a high-energy intermediate carrier of phosphoryl groups, linking catabolic pathways that release energy to anabolic pathways that require it. This cycle allows for the efficient and regulated transfer of chemical energy to perform mechanical work, transport, and various biosynthetic reactions.

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dehydrogenase. Because malonate cannot be oxidized, it effectively blocks the reaction, halting the citric acid cycle at this step. This specific inhibition was historically used to elucidate the cycle's sequence.

253. (D) Citrate
Citrate is an intermediate of the citric acid cycle that also plays a role in regulating the flow of metabolites between different pathways. When the cycle is saturated and energy is abundant, citrate can be transported out of the mitochondria into the cytosol. There, it acts as a potent allosteric inhibitor of phosphofructokinase-1, the rate-limiting enzyme of glycolysis, signaling energy excess.

254. (C) Depletion of cycle intermediates leading to reduced acetyl-CoA oxidation
Anaplerotic reactions are essential for maintaining the concentration of citric acid cycle intermediates. If these reactions fail to function, the intermediates that are diverted into biosynthetic pathways, such as gluconeogenesis or amino acid synthesis, are not replenished. This leads to a rapid depletion of the cycle's components, which eventually halts the oxidation of acetyl-coenzyme A and severely impairs cellular energy production.

255. (B) 3-carbon moiety
Transaldolase is an enzyme that works in the non-oxidative phase of the pentose phosphate pathway. Unlike transketolase, it facilitates the transfer of a three-carbon dihydroxyacetone fragment from a ketose donor to an aldose acceptor. This reaction does not require any cofactors and is essential for the interconversion of three-, four-, seven-, and six-carbon sugars in various metabolic scenarios.

256. (D) Inability to produce NADPH to maintain glutathione against oxidative damage
In glucose-6-phosphate dehydrogenase deficiency, red blood cells are unable to generate sufficient NADPH via the pentose phosphate pathway. NADPH is absolutely required to keep glutathione in its reduced state. Reduced glutathione is the essential substrate for neutralizing reactive oxygen species. Without it, oxidative damage to hemoglobin and membrane proteins causes the cell to become fragile and undergo premature lysis.

257. (A) High demand for fatty acid biosynthesis during the fed state
The activity of the pentose phosphate pathway is highly upregulated in adipose tissue during the well-fed state. This is because the synthesis of fatty acids from acetyl-coenzyme A requires a large and steady supply of reducing power in the form of NADPH. The pentose phosphate pathway is the primary source of this NADPH, linking glucose metabolism to lipid storage.

258. (C) Highly frequent alpha-1,6 branch points resulting in more compact structures
Glycogen and starch are both polymers of glucose, but they differ significantly in their degree of branching. Glycogen is much more highly branched than amylopectin, the branched component of starch, with branch points occurring every eight to twelve residues. This highly compact and branched structure provides many more non-reducing ends for rapid enzymatic breakdown and release of glucose molecules.

259. (A) I, II, III, IV
Glycogen synthase is primarily regulated by reversible phosphorylation. It is inactivated when phosphorylated by kinases like GSK-3 and activated when dephosphorylated in response to insulin. It also possesses a strong allosteric activator in the form of glucose-6-phosphate. Statement V is incorrect because glucagon, signaling low energy, promotes the phosphorylation and inactivation of the enzyme to prevent glycogen storage.

260. (A) P-3, Q-1, R-2, S-4
Metabolic diseases have distinct biochemical characteristics. Diabetic ketoacidosis is marked by unrestrained lipolysis and ketone overproduction. Fatty liver syndrome in cattle involves an excess influx of non-esterified fatty acids that the liver cannot export as VLDLs. Familial hypercholesterolemia is caused by a defect in LDL receptors. Finally, gout is characterized by the deposition of monosodium urate crystals in joint tissues.

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261. (B) Glycogen phosphorylase
Pyridoxal phosphate is a versatile cofactor that is uniquely essential for the function of glycogen phosphorylase. Unlike its role in transamination, PLP in this enzyme acts as a general acid-base catalyst, specifically utilizing its phosphate group

243. (A) It traps glucose inside the cell and destabilizes it for further cleavage
The phosphorylation of glucose to glucose-6-phosphate by hexokinase serves two major metabolic functions. First, it adds a negative charge to the molecule, which prevents it from being transported back across the cell membrane, effectively trapping it inside the cell. Second, the addition of the phosphate group begins the process of destabilizing the glucose molecule for subsequent enzymatic cleavage reactions.

244. (D) Aldolase
Aldolase is the glycolytic enzyme responsible for the cleavage of the six-carbon sugar fructose-1,6-bisphosphate into two three-carbon fragments. This reaction breaks a carbon-carbon bond, resulting in the formation of dihydroxyacetone phosphate and glyceraldehyde-3-phosphate. This step is a critical junction in the pathway, as it converts the hexose sugars into the triose phosphates that continue through the payoff phase.

245. (B) Transport of reducing equivalents into the mitochondria via shuttles for the ETC
For glycolysis to continue under aerobic conditions, the NADH produced in the cytosol must be reoxidized to NAD+. Since the mitochondrial membrane is impermeable to NADH, reducing equivalents are transferred into the matrix using specialized shuttle systems, such as the malate-aspartate or glycerol-3-phosphate shuttles. Once inside, these electrons enter the respiratory chain to generate ATP and regenerate NAD+.

246. (A) II, III and IV
Fructose-2,6-bisphosphate is a potent regulatory molecule, not an intermediate of the glycolytic pathway. It acts as a major allosteric activator of phosphofructokinase-1 and a strong inhibitor of fructose-1,6-bisphosphatase. Its levels are regulated by insulin and glucagon, ensuring that the rates of glycolysis and gluconeogenesis in the liver are reciprocically controlled according to the body's overall blood glucose status.

247. (D) Phosphoglycerate mutase
The isomerization of 3-phosphoglycerate to 2-phosphoglycerate is catalyzed by the enzyme phosphoglycerate mutase. This reaction involves the internal transfer of a phosphoryl group from the third carbon to the second carbon of the molecule. This shift is necessary to prepare the substrate for the subsequent dehydration reaction, which creates the high-energy enol phosphate bond found in phosphoenolpyruvate.

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248. (A) Glucose-6-phosphate to free Glucose
Von Gierke's disease is fundamentally a defect in the final common step of glucose production by the liver. Due to the deficiency of glucose-6-phosphatase, the liver is unable to remove the phosphate group from glucose-6-phosphate. As a result, the glucose produced from both glycogen breakdown and gluconeogenesis remains trapped as glucose-6-phosphate, leading to a failure in maintaining blood sugar.

249. (B) Terminal sulfhydryl (-SH) group
Coenzyme A is a versatile carrier of acyl groups in various metabolic reactions. Its reactive functional group is a terminal sulfhydryl, or thiol, group. Acyl groups are attached to this sulfur atom via a high-energy thioester bond. This structure allows the coenzyme to activate acyl groups for transfer to other molecules or for entry into the citric acid cycle as acetyl-CoA.

250. (A) Both A and R are true and R is the correct explanation of A.
The citric acid cycle is correctly described as an amphibolic pathway because it plays a dual role in metabolism. It is catabolic because it oxidizes acetyl-coenzyme A to release energy and carbon dioxide. Simultaneously, it is anabolic because several of its intermediates, such as alpha-ketoglutarate and oxaloacetate, serve as essential precursors for the biosynthesis of amino acids and porphyrins.

251. (A) NADH and CO_2
Isocitrate dehydrogenase catalyzes the first of two oxidative decarboxylation steps in the citric acid cycle. During this reaction, isocitrate is oxidized to alpha-ketoglutarate, resulting in the production of one molecule of NADH and the release of one molecule of carbon dioxide. This step is a major site of regulation, being allosterically activated by ADP and inhibited by ATP and NADH.

252. (C) Succinate dehydrogenase
Malonate is a classic example of a competitive inhibitor because it is structurally similar to succinate. It competes with succinate for binding at the active site of the enzyme succinate

provides sequence-specific protection against repeated infections.

290. (A) I, II, III
A CRISPR-Cas9-mediated gene knockout via non-homologous end joining (NHEJ) requires Cas9 endonuclease, a single guide RNA (sgRNA) to direct Cas9 to the target sequence, and a Protospacer Adjacent Motif (PAM) adjacent to the target. A donor DNA template and viral delivery vector are unnecessary because NHEJ creates insertions or deletions without introducing new DNA.

291. (A) AAV (Adeno-associated virus)
Adeno-associated virus (AAV) is widely used for in vivo liver-directed gene therapy because it efficiently transduces hepatocytes, has low immunogenicity, and usually persists as episomal DNA, allowing long-term expression without frequent genome integration. These properties make AAV an excellent vector for treating metabolic disorders such as phenylketonuria (PKU).

292. (D) Propensity to elicit robust and potentially fatal systemic immune responses
A major limitation of adenoviral vectors is their ability to trigger strong innate and adaptive immune responses, which can lead to inflammation and, in severe cases, life-threatening systemic toxicity. Although adenoviruses efficiently infect dividing and non-dividing cells and accommodate large DNA inserts, their immunogenicity restricts repeated therapeutic administration.

293. (B) Cas9 mRNA and the guide RNA
Lipid nanoparticles (LNPs) commonly deliver Cas9 mRNA together with the guide RNA (gRNA) into target cells. The mRNA is translated into Cas9 protein inside the cell, which then complexes with the guide RNA to perform targeted genome editing. This transient delivery reduces prolonged Cas9 expression and lowers the risk of off-target effects.

294. (C) Modification of non-reproductive cells without affecting future generations
Somatic gene transfer targets non-reproductive (somatic) cells, so the genetic changes remain confined to the treated individual and are not inherited by offspring. In contrast, germline gene transfer modifies reproductive cells or embryos, making the alterations heritable. This distinction is fundamental to the ethical and regulatory considerations of gene therapy.

295. (D) AAV9
AAV9 is the viral vector successfully used for treating Spinal Muscular Atrophy (SMA) because it can cross the blood-brain barrier and efficiently transduce motor neurons. It delivers a functional SMN_1 gene, restoring protein production and improving motor function. Its favorable safety profile has made AAV9 a landmark vector in neurological gene therapy.

296. (A) Early S to G_2 phase
Homology-Directed Repair (HDR) is most active during the early S to G_2 phases of the cell cycle, when a sister chromatid or supplied donor DNA template is available for accurate DNA repair. Consequently, CRISPR-based precise gene editing using HDR is most efficient in actively dividing cells during these phases.

297. (B) The unintended cleavage of DNA sequences that are partially complementary to the sgRNA
Off-target effects occur when the Cas9-sgRNA complex binds and cleaves DNA sequences that are similar, but not identical, to the intended target. Such unintended mutations can disrupt unrelated genes or regulatory regions, posing safety concerns. Careful guide RNA design and high-fidelity Cas9 variants help minimize off-target genome editing.

298. (A) I, II, IV
Non-viral gene delivery systems, such as liposomes, commonly exhibit transient transgene expression, lower transfection efficiency than viral vectors, and endosomal entrapment, which reduces intracellular delivery. Unlike integrating viral vectors, they generally have a low risk of insertional mutagenesis and are less immunogenic, making repeated administration more feasible.

299. (A) Writes new genetic information without requiring double-strand breaks
Prime editing is an advanced CRISPR technology that introduces precise genetic changes without creating double-strand DNA breaks or requiring donor DNA templates. It uses a Cas9 nickase fused to reverse transcriptase and a prime editing guide RNA (pegRNA) to directly write new genetic information, reducing unwanted mutations and improving editing precision.

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to facilitate the phosphorolysis of the alpha-1,4 glycosidic bond. This requirement makes it an indispensable component for the mobilization of glucose from stored glycogen.

262. (C) Biotin and Vitamin B_{12}
The catabolism of odd-chain fatty acids produces propionyl-coenzyme A, which must be converted to succinyl-coenzyme A to enter the citric acid cycle. This specialized pathway requires two different B vitamins as coenzymes. Biotin is needed for the carboxylation of propionyl-CoA, and vitamin B_{12}, in the form of deoxyadenosylcobalamin, is required for the subsequent rearrangement of methylmalonyl-CoA into succinyl-CoA.

263. (D) Rumen epithelium
In ruminant animals, the vast majority of dietary carbohydrates are fermented by microbes into volatile fatty acids. These short-chain fatty acids are primarily absorbed directly across the rumen epithelium into the portal bloodstream. This efficient absorption mechanism provides the animal with its primary source of energy and carbon skeletons for various metabolic processes, bypassing the need for extensive intestinal glucose absorption.

264. (A) Carnitine palmitoyltransferase I (CPT-I)
Malonyl-coenzyme A acts as a critical regulatory molecule that prevents a futile cycle between fatty acid synthesis and breakdown. When fatty acid synthesis is active in the cytosol, high levels of malonyl-CoA are produced. This molecule then acts as a potent inhibitor of carnitine palmitoyltransferase 1, thereby preventing the transport of fatty acids into the mitochondria for beta-oxidation during synthesis.

265. (B) Homodimer with multiple enzymatic domains on one polypeptide chain
The mammalian fatty acid synthase is a highly complex multienzyme system. It is structurally organized as a homodimer, where each large polypeptide chain contains all seven independent catalytic domains required for the synthesis of palmitate. This arrangement allows for efficient substrate channeling between the different active sites, significantly increasing the overall rate and coordination of the biosynthetic process.

266. (B) Endoplasmic reticulum
While the de novo synthesis of saturated fatty acids occurs in the cytosol, the introduction of double bonds to form unsaturated fatty acids takes place in the endoplasmic reticulum. This process is catalyzed by a family of membrane-bound enzymes known as fatty acid desaturases. These enzymes require molecular oxygen, NADH, and a specific electron transport chain involving cytochrome b5 to function.

NODIA

267. (A) Propionate
Because dietary carbohydrates are almost completely fermented in the rumen, ruminants absorb very little glucose from their digestive tract. Instead, they rely on continuous hepatic gluconeogenesis to maintain stable blood glucose levels. The three-carbon volatile fatty acid propionate is the most significant substrate for this process, accounting for the vast majority of the glucose synthesized in these animals.

268. (C) Limited oxaloacetate levels forcing excess acetyl-CoA into ketogenic pathways
During early lactation, dairy cows experience an intense demand for glucose and amino acids for milk synthesis. This high demand depletes the liver's supply of oxaloacetate as it is diverted toward gluconeogenesis. When oxaloacetate is scarce, the acetyl-coenzyme A generated from mobilized fatty acids cannot enter the citric acid cycle and is instead diverted toward the production of ketones.

269. (D) HMG-CoA
The first statin drugs, which are widely used to lower blood cholesterol levels, were developed based on their structural similarity to HMG-coenzyme A, the natural substrate for HMG-CoA reductase. Because of this similarity, statins act as potent competitive inhibitors of the enzyme. By blocking the synthesis of mevalonate, they effectively reduce the de novo production of cholesterol in cells.

270. (A) I and III
Ammonia is highly neurotoxic to the central nervous system and must be rapidly detoxified. Glutamate dehydrogenase plays a central role in this process by catalyzing the oxidative deamination of glutamate to release ammonia in the liver. Statement II is incorrect because urea is synthesized in the liver and then transported to the kidneys for excretion in the urine.

CHAPTER 06
Transcription and Traslation

2002

1. Which of the following parameters represents the axial rise per base pair in the canonical Watson-Crick B-DNA double helix?
(A) 0.15 nm
(B) 0.34 nm
(C) 2.0 nm
(D) 3.4 nm

2018

2. Under physiological conditions, which distinct conformational feature uniquely characterizes Z-DNA compared to A-DNA and B-DNA?
(A) Right-handed helical sense possessing a well-defined major groove
(B) Parallel orientation of the complementary polynucleotide strands
(C) Left-handed rotation with a zigzag sugar-phosphate backbone
(D) Complete absence of minor grooves within the structural fold

2025

3. In the context of nucleotide chemistry, which carbon atom of the pentose sugar forms the N-glycosidic linkage with the nitrogenous base?
(A) C1'
(B) C_2'
(C) C3'
(D) C_5'

2013

4. Identify the correct statement regarding the structural conformation of A-form DNA.
(A) Left-handed double helix which is adopted under high humidity
(B) Base pairs strictly perpendicular to the helical axis, unlike B-DNA
(C) Alternating purine-pyrimidine tracts required for stability
(D) Wide and compressed structure forming under dehydrated conditions

2021

5. Evaluate the following statements regarding the chemical differences between RNA and DNA and identify the INCORRECT one.
(A) RNA contains a 2'-hydroxyl group, rendering it more susceptible to alkaline hydrolysis.
(B) The ribose sugar in RNA favors a C_2'-endo conformation, exclusively forming B-form helices.
(C) Thymine in DNA is formed via the methylation of uracil at the C_5 position.
(D) DNA predominantly utilizes a 2'-deoxyribose sugar to increase structural stability.

2016

6. Identify the correct pair matching the DNA conformation to its typical helical diameter.
(A) A-DNA : 1.8 nm
(B) B-DNA : 2.6 nm
(C) Z-DNA : 1.8 nm
(D) B-DNA : 1.8 nm

2023

7. Identify the INCORRECT pair regarding the complementary hydrogen bonding in the Watson-Crick model.
(A) Adenine-Thymine : Two hydrogen bonds
(B) Guanine-Cytosine : Three hydrogen bonds
(C) N6 of Adenine : Hydrogen bond donor
(D) O6 of Guanine : Hydrogen bond donor

2023

8. All of the following are stabilizing forces in the Watson-Crick DNA double helix, EXCEPT:
(A) Hydrophobic interactions between phosphate groups
(B) Base stacking interactions
(C) Hydrogen bonding between bases
(D) Covalent phosphodiester linkages

2021

9. Which molecular interaction provides the most significant thermodynamic contribution to the stability of the DNA double helix?
(A) Inter-strand hydrogen bonding
(B) Base stacking interactions
(C) Electrostatic repulsion of phosphates
(D) Dipole-induced dipole forces in the sugar

2021

10. Analyze the following assertion and reason and select the correct option from (A) to (D).
Assertion (A): Z-DNA is favored in sequences with

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correctly describe these distinct biosynthetic approaches.

281. (B) Carbamoyl phosphate synthetase II (CPS-II)
In mammalian cells, the rate-limiting and committed step of pyrimidine biosynthesis is catalyzed by the cytosolic enzyme carbamoyl phosphate synthetase II. This enzyme is part of a large multifunctional complex called CAD. CPS-II is allosterically inhibited by UTP, the end product of the pathway, and activated by PRPP, ensuring that the rate of pyrimidine synthesis is matched to cellular needs.

282. (B) It is oxidized to Dihydrofolate (DHF)
The conversion of dUMP to dTMP by thymidylate synthase is a unique reaction in folate metabolism. N5,$N_1$0-methylene-tetrahydrofolate acts as both a carbon donor and a reducing agent. During the transfer of the methyl group, the tetrahydrofolate coenzyme is oxidized to dihydrofolate. This dihydrofolate must then be reduced back to tetrahydrofolate by dihydrofolate reductase to maintain the nucleotide biosynthetic pool.

283. (A) Dihydrofolate reductase (DHFR)
Methotrexate is a powerful chemotherapeutic drug that acts as a structural analog of folic acid. It functions by binding with extremely high affinity to the enzyme dihydrofolate reductase, thereby inhibiting the regeneration of tetrahydrofolate from dihydrofolate. This leads to a depletion of the folate cofactors needed for thymidylate and purine synthesis, effectively halting DNA replication in rapidly dividing cancer cells.

284. (C) Oxypurinol
When allopurinol is administered, it is first acted upon by the enzyme xanthine oxidase, which converts it into its active metabolite, oxypurinol. Unlike allopurinol, oxypurinol binds much more tightly to the molybdenum center of the enzyme. This binding is essentially irreversible, making oxypurinol a potent suicide inhibitor that effectively prevents the formation of uric acid in the body.

285. (D) Ribonucleotide reductase
In patients with adenosine deaminase deficiency, the failure to catabolize deoxyadenosine leads to its excessive phosphorylation into dATP. High levels of dATP act as a universal and potent allosteric inhibitor of ribonucleotide reductase. By blocking the production of all deoxyribonucleoside triphosphates, dATP prevents DNA synthesis and cell division, which is the primary cause of severe lymphopenia in SCID.

286. (C) Dopamine
Although Lesch-Nyhan syndrome is primarily a disorder of purine metabolism, its severe neurological symptoms are believed to result from a secondary dysfunction of the brain's dopamine system. Research indicates that the lack of purine salvage significantly impairs the development and function of dopaminergic neurons in the basal ganglia. This deficiency is thought to drive the characteristic motor and behavioral abnormalities.

287. (B) Gammaretrovirus
Gammaretroviruses are a type of viral vector that can integrate their genetic material into the host genome, but they are generally unable to cross the nuclear envelope. Therefore, they can only infect and transduce cells that are actively dividing, where the nuclear membrane breaks down. This characteristic makes them suitable for ex vivo modification of hematopoietic stem cells but poor for neurons.

NODIA

288. (D) An extrachromosomal circular DNA molecule that replicates independently or persists without integrating
In the context of gene therapy, an episome is a molecule of genetic material that remains and functions within the cell nucleus without integrating into the host's chromosomal DNA. Episomal vectors, such as adeno-associated viruses, persist as independent circular units that can be transcribed to produce therapeutic proteins. This non-integrating approach is often preferred because it avoids the risks of mutagenesis.

289. (A) Adaptive immunity against bacteriophages and plasmids
The CRISPR-Cas system evolved in bacteria and archaea as an adaptive immune defense against invading bacteriophages and plasmids. Short fragments of foreign DNA are incorporated into CRISPR arrays and later transcribed into guide RNAs that direct Cas proteins to recognize and cleave matching foreign nucleic acids. This

233. (B) The large atomic radius of sulfur preventing orbital overlap and resonance stabilization
The high free energy of hydrolysis of thioesters is primarily due to the lack of significant resonance stabilization between the carbonyl group and the sulfur atom. Because the sulfur atom is larger than the oxygen atom, there is poor orbital overlap, preventing the delocalization of electrons. This results in a higher ground-state energy for thioesters compared to ordinary oxygen esters.

234. (B) All carriers accumulate in their reduced state, halting electron flow
Molecular oxygen is the final electron acceptor of the mitochondrial respiratory chain. In its absence, the last complex cannot pass its electrons forward and remains in a reduced state. This back-up quickly affects all preceding complexes in the chain, causing all electron carriers to accumulate in their reduced forms. Consequently, electron flow and the associated proton pumping completely halt.

235. (A) Fe2+ and Fe3+
Iron-sulfur clusters are essential prosthetic groups found in several complexes of the electron transport chain. They act as one-electron carriers by undergoing reversible oxidation and reduction between the ferrous and ferric states. These clusters are strategically positioned to facilitate the rapid movement of electrons through the protein complexes toward the mobile carriers ubiquinone and cytochrome c.

236. (C) Copper
Cytochrome c oxidase is the terminal complex of the electron transport chain and is responsible for reducing oxygen to water. It contains two essential copper centers, known as CuA and CuB, in addition to heme a and a3. These copper ions are critical for the sequential transfer of electrons and for holding the oxygen molecule in place during its reduction.

237. (C) 10
When a pair of electrons from one molecule of NADH passes through the entire mitochondrial electron transport chain, a total of ten protons are pumped across the inner membrane. Specifically, four protons are translocated at complex I, four at complex III, and two at complex IV. This establishes the electrochemical gradient that powers the synthesis of ATP by ATP synthase.

238. (C) Function as an ATP hydrolase (ATPase)
The F_1 subunit of the ATP synthase complex contains the catalytic sites for synthesis. However, without the coupling provided by the Fo subunit and the proton motive force, the enzyme naturally favors the reverse reaction. If physically detached from the membrane, F_1 functions as an ATP hydrolase, or ATPase, breaking down ATP into ADP and inorganic phosphate.

239. (B) Oligomycin
The Fo portion of the mitochondrial ATP synthase is specifically sensitive to the antibiotic oligomycin. By binding to a site on the c-ring, oligomycin physically blocks the return of protons into the matrix. This inhibition of the proton channel prevents the rotation of the enzyme and consequently halts all ATP synthesis, effectively acting as a potent respiratory inhibitor in cells.

240. (D) The b2-delta peripheral stalk complex
The structural integrity and function of the ATP synthase depend on a static component called the stator. In mitochondrial ATP synthase, the stator is composed of the b2 and delta subunits, which form a peripheral stalk. This stalk anchors the alpha3-beta3 catalytic hexamer to the membrane-embedded a-subunit, preventing the hexamer from rotating along with the central gamma subunit.

241. (A) Succinate oxidation bypasses the proton-pumping Complex I
The P/O ratio for succinate oxidation is lower than that for NADH because electrons from succinate enter the respiratory chain at complex II via FADH2. Complex II does not pump any protons across the membrane. Since the electrons bypass the four protons normally pumped by complex I, fewer total protons are translocated per pair of electrons, resulting in less ATP.

242. (C) Lipophilic weak acids
Chemical uncouplers of oxidative phosphorylation, such as 2,4-dinitrophenol, are typically small, lipophilic weak acids. This structure allows them to dissolve in the mitochondrial membrane and exist in both protonated and deprotonated forms. They can pick up a proton from the intermembrane space and carry it directly across the lipid bilayer into the matrix, thereby short-circuiting the proton gradient.

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300. (C) Large Factor VIII gene size exceeds the packaging capacity of AAV vectors
The Factor VIII gene is too large to fit within the limited ~4.7 kb packaging capacity of AAV vectors. Therefore, lentiviral vectors, which can accommodate larger genetic inserts and integrate into hematopoietic stem cells for long-term expression, are preferred for ex vivo gene therapy approaches in Hemophilia A.

****

NODIA

271. (B) Pyridoxamine phosphate (PMP)
Transamination reactions follow a specific double-displacement, or ping-pong, kinetic mechanism. In the first half-reaction, the amino acid substrate reacts with the enzyme-bound pyridoxal phosphate to form a Schiff base, which then releases the keto acid and leaves the amino group attached to the cofactor. This temporary form of the cofactor is known as pyridoxamine phosphate, which then reacts further.

272. (D) Neutral and highly water-soluble
Urea is the ideal nitrogenous waste product for mammals because of its favorable chemical properties. It is a small, uncharged, and neutral molecule that is highly soluble in water. These characteristics allow it to diffuse easily across cell membranes and be transported safely through the blood at relatively high concentrations without affecting the body's pH or causing significant toxicity.

273. (A) The Citric Acid Cycle
When ammonia levels are excessively high, the brain attempts to detoxify it by synthesizing glutamate and then glutamine. This process consumes alpha-ketoglutarate, which is a key intermediate of the citric acid cycle. The resulting depletion of alpha-ketoglutarate directly impairs the function of the cycle, leading to a failure in mitochondrial energy production and contributing to severe neurological damage.

274. (C) Tyrosine
Alkaptonuria is an inborn error in the catabolic pathway of the aromatic amino acids phenylalanine and tyrosine. Specifically, it results from a deficiency in the enzyme homogentisate dioxygenase, which is responsible for cleaving the aromatic ring of homogentisic acid. The inability to process this intermediate leads to its accumulation and subsequent excretion in the urine, resulting in pathognomonic symptoms.

275. (A) Phenylalanine
In patients with phenylketonuria, the normal pathway for phenylalanine metabolism is blocked due to an enzyme deficiency. As a result, phenylalanine accumulates and is diverted into an alternative minor pathway. In this pathway, phenylalanine undergoes transamination with an alpha-keto acid to form phenylpyruvate. This phenylketone is a toxic metabolite that is excreted in the urine, giving the disease its name.

276. (D) One nitrogen atom
The urea molecule contains two nitrogen atoms, each coming from a different source. One nitrogen atom is donated by the amino acid aspartate during the middle stage of the urea cycle. Aspartate combines with citrulline in the cytosol to form argininosuccinate. This reaction incorporates the amino group from aspartate into the growing molecule, which is eventually released as urea.

277. (B) Fumarate
The urea cycle and the citric acid cycle are interconnected through several common intermediates. Fumarate, which is produced in the cytosol when argininosuccinate is cleaved by argininosuccinate lyase, serves as a major bridge between the two pathways. It can be converted to malate, which then enters the mitochondria to be oxidized in the citric acid cycle, providing energy and linkage.

278. (C) N-acetylglutamate
The short-term regulation of the urea cycle is achieved through the allosteric control of its first enzyme, carbamoyl phosphate synthetase 1. This enzyme has an absolute requirement for N-acetylglutamate as an activator. The synthesis of N-acetylglutamate is itself stimulated by arginine, effectively increasing the rate of urea production when there is a high flux of amino acids through the liver.

279. (D) Epinephrine and Melanin
Tyrosine is a multifunctional amino acid that serves as a precursor for several biologically significant molecules. It is the starting point for the synthesis of catecholamine neurotransmitters, including dopamine, norepinephrine, and epinephrine. Additionally, tyrosine is the essential substrate for the production of melanin pigments in the skin and hair, as well as the thyroid hormones triiodothyronine and thyroxine.

280. (A) I and II
Purine and pyrimidine biosynthesis follow fundamentally different strategies. For purines, the bicyclic ring is constructed atom by atom directly onto a ribose phosphate backbone provided by PRPP. In contrast, the pyrimidine ring is first synthesized as a complete six-membered structure before it is attached to the PRPP molecule. Both statements I and II

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alternating purines and pyrimidines, particularly when cytosine residues are methylated.

Reason (R): Methylation of cytosine at the C_5 position stabilizes the Z-conformation by reducing the energy barrier for the B-to-Z transition.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

11. If a double-stranded DNA molecule contains 20% adenine, what is the percentage of cytosine in the molecule?
(A) 20%
(B) 30%
(C) 40%
(D) 60%

2018

12. A mutation disrupting the syn conformation of guanine residues would most directly impede the formation of which DNA structure?
(A) A-DNA
(B) B-DNA
(C) Z-DNA
(D) Triple-stranded DNA

2004

13. Which of the following best classifies the histones H2A, H2B, H3, and H4?
(A) Acidic structural proteins
(B) Linker nucleoproteins
(C) Scaffold attachment factors
(D) Core octameric proteins

2010

14. When comparing prokaryotic and eukaryotic genome organization, which structural feature is exclusively observed in eukaryotes?
(A) Circular double-stranded DNA
(B) Supercoiled topological domains
(C) Nucleosome core particles
(D) Operon-based gene clusters

2012

15. Which of the following is the most relevant factor determining the highly basic nature of histone proteins?
(A) High enrichment of aspartate and glutamate residues
(B) Abundance of lysine and arginine residues
(C) Post-translational addition of acetyl groups
(D) Presence of heavily glycosylated serine residues

2005

16. In the structure of the nucleosome, the linker DNA is primarily protected by which protein?
(A) Histone H3
(B) DNA topoisomerase II
(C) High Mobility Group (HMG) proteins
(D) Histone H1

2001

17. Which ATP-dependent chromatin remodeling complex is primarily known for replacing core histones with histone variants?
(A) SWR1 complex
(B) SWI/SNF complex
(C) ISWI complex
(D) CHD complex

2009

18. What is a primary structural advantage of extensive chromatin remodeling during eukaryotic transcription?
(A) It permanently denatures the DNA double helix.
(B) It removes all epigenetic methylation marks simultaneously.
(C) It facilitates the accessibility of the promoter to RNA polymerase.
(D) It converts the entire chromosome into heterochromatin.

2023

19. The fundamental repeating unit of eukaryotic chromatin, containing approximately 147 base pairs of DNA wrapped around an octamer, is defined as a:
(A) Nucleosome
(B) Solenoid
(C) Chromatosome
(D) Replisome

2018

20. Match the chromatin structural levels in List I with their approximate diameters in List II.

List I: (Structural Level)
P. DNA double helix
Q. Nucleosome fiber
R. Solenoid fiber
S. Chromatid

List II: (Diameter)
1. 2 nm
2. 11 nm
3. 30 nm
4. 700 nm

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(A) Single base mutation alters only one amino acid
(B) Certain amino acids are coded by six different codons
(C) The code utilizes exactly three nucleotides per amino acid
(D) Plasmids can be exchanged between different bacterial species

2013

83. Identify the correct statement regarding variant features of the genetic code in human mitochondria.
(A) UGA codes for Tryptophan instead of acting as a stop
(B) AUG acts as a stop codon instead of coding for Methionine
(C) The mitochondrial code utilizes completely different bases
(D) Mitochondrial DNA lacks any functional stop codons

2022

84. Evaluate the statements regarding reading frames in mRNA and identify the INCORRECT one.
(A) An mRNA sequence generally possesses three possible frames
(B) The open reading frame (ORF) is determined by the start codon
(C) Ribosomes translate all three reading frames simultaneously
(D) Frameshift mutations shift the translational reading frame

2008

85. Identify the correct statement involving translation machinery components.
(A) Ribosome 70S : Eukaryotic cytosol
(B) Ribosome 80S : Prokaryotic cytosol
(C) Aminoacyl-tRNA synthetase : Peptide bond formation
(D) Peptidyl transferase center : Large ribosomal subunit

2024

86. Identify the INCORRECT pair regarding the structure of ribosomes.
(A) Prokaryotic large subunit : 50S
(B) Prokaryotic small subunit : 30S
(C) Eukaryotic large subunit : 60S
(D) Eukaryotic small subunit : 50S

2016

87. All of the following directly ensure the enzymatic fidelity of aminoacyl-tRNA synthetases EXCEPT:
(A) High specificity for a single amino acid
(B) Specific recognition of the tRNA anticodon
(C) Proofreading/editing functional domains
(D) Reliance on the ribosome for amino acid verification

2018

88. Which process provides the most accurate and definitive selection of the correct amino acid during tRNA charging?
(A) Double-sieve mechanism of aminoacyl-tRNA synthetases
(B) Thermodynamic stability of the peptide bond formation
(C) Binding of initiation factors to the small ribosomal subunit
(D) Phosphorylation of the tRNA molecule at the acceptor stem

2016

89. A chemical inhibitor that permanently blocks the editing site of isoleucyl-tRNA synthetase will cause:
(A) Premature termination of all cellular protein synthesis
(B) Misincorporation of valine in place of isoleucine
(C) Complete failure of the large ribosomal subunit to associate
(D) Rapid degradation of the mRNA template by exonucleases

2008

90. Which of the following is an INCORRECT representation of ribosomal biogenesis in eukaryotes?
(A) It primarily occurs within the nucleolus.
(B) It requires the transcription of 45S precursor rRNA by RNA Pol I.
(C) It involves the assembly of ribosomal proteins transcribed in the cytoplasm and imported to the nucleus.
(D) The 5S rRNA is transcribed by RNA Pol I within the nucleolus.

2014

91. The enzymatic charging of a tRNA molecule by aminoacyl-tRNA synthetase is an ATP-dependent reaction that generates an intermediate known as:
(A) Aminoacyl-GMP
(B) Aminoacyl-AMP

NODIA

2004

31. Application of a drug that prevents the sealing of the transient double-strand break formed by Topoisomerase II will result in:
(A) Unregulated transcription rates
(B) Fragmentation of the genomic DNA
(C) Enhanced replisome velocity
(D) Over-synthesis of RNA primers

2003

32. Which phenomenon is a direct cause of the requirement for Okazaki fragments during prokaryotic DNA replication?
(A) High processivity and speed of DNA polymerase I molecules
(B) Continuous unwinding action of the DNA gyrase complex
(C) Bidirectional origin of replication located at the oriC site
(D) Antiparallel DNA nature and strict 5' to 3' synthesis

2012

33. The complex of multiple proteins responsible for coordinated DNA replication at the fork is termed the:
(A) Replisome
(B) Spliceosome
(C) Proteasome
(D) Nucleosome

2023

34. In comparing DNA Polymerase I and III in E. coli, which catalytic activity is unique to DNA Polymerase I?
(A) 5' to 3' polymerase activity
(B) 3' to 5' exonuclease activity
(C) 5' to 3' exonuclease activity
(D) ATP-dependent ligase activity

2014

35. Identify the correct statement detailing prokaryotic replication initiation.
(A) DnaA binds 9-mers in oriC to unwind the 13-mer region.
(B) Primase continuously synthesizes RNA on the leading strand template.
(C) Replication initiates randomly at multiple origins across the chromosome.
(D) DNA Polymerase I is the principal replicative enzyme at initiation.

2011

36. Evaluate the following statements regarding the role of Okazaki fragments and identify the INCORRECT one.
(A) They are synthesized on the lagging strand template.
(B) They require transient RNA primers for initiation.
(C) They are eventually joined together by DNA ligase.
(D) They are polymerized in the 3' to 5' direction.

2002

37. Identify the correct pair involving E. coli replication components and their specific functions.
(A) DnaB : Origin recognition protein
(B) DnaG : RNA primase
(C) DnaC : Ligase
(D) SSB : 3' to 5' exonuclease

2018

38. Identify the INCORRECT pair regarding the subunits of the DNA polymerase III holoenzyme.
(A) Alpha subunit : Polymerase activity
(B) Epsilon subunit : 3' to 5' proofreading exonuclease
(C) Theta subunit : RNA primer removal
(D) Beta clamp : Processivity factor

2004

39. Which enzyme is most responsible for the removal of RNA primers in prokaryotic DNA replication?
(A) DNA Polymerase III
(B) RNase H
(C) DNA Ligase
(D) DNA Polymerase I

2012

40. Consider the following statements regarding prokaryotic replisome components.
I. DnaA is a helicase loader.
II. Single-stranded binding proteins (SSB) prevent secondary structure formation.
III. The beta-clamp requires a clamp loader complex (gamma complex).
IV. DNA ligase utilizes NAD+ or ATP for phosphodiester bond formation.
Which of the above statement(s) is/are INCORRECT?
(A) I and III
(B) II and III
(C) I only
(D) IV only

2007

41. Eukaryotic DNA replication differs fundamentally from prokaryotic replication in that eukaryotes:
(A) Utilize a single origin of replication

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(A) Utilization of nucleoside triphosphates
(B) Synthesis in the 5' to 3' direction
(C) Requirement for extensive chromatin remodeling
(D) De novo synthesis without a primer

2018

63. Which is the least relevant component for the initiation of transcription by eukaryotic RNA Polymerase I?
(A) Upstream Binding Factor (UBF)
(B) Selectivity Factor 1 (SL1)
(C) Core promoter element
(D) TATA-binding protein associated factors (TAFs) of RNA Pol II

2018

64. Post-transcriptional modification involving the addition of a 7-methylguanosine cap to the 5' end of eukaryotic mRNA is primarily defined as:
(A) Polyadenylation
(B) Splicing
(C) RNA editing
(D) 5' Capping

2019

65. The 5' cap structure in eukaryotic mRNA is formed via which unique linkage?
(A) 3'-5' phosphodiester bond
(B) 5'-5' triphosphate linkage
(C) 2'-5' phosphodiester bond
(D) Glycosidic linkage

2012

66. Identify the correct statement regarding 3' polyadenylation in eukaryotes.
(A) Is template-directed by a poly-T tract in the DNA
(B) Cleaves pre-mRNA downstream of the AAUAAA signal
(C) Is catalyzed by RNA Polymerase II during elongation
(D) Strictly prevents the export of mRNA to the cytoplasm

2019

67. Evaluate the statements regarding spliceosome-mediated RNA splicing and identify the INCORRECT one.
(A) Removes intronic sequences and ligates exon regions together
(B) Operates via two sequential transesterification reactions
(C) Involves the 2'-OH of a conserved adenosine in the first step
(D) Excises the intron in a characteristic lariat structure

2013

68. Identify the correct pair matching the small nuclear ribonucleoprotein (snRNP) to its splicing function.
(A) U1 : Binds the 5' splice site
(B) U2 : Binds the 3' splice site directly
(C) U4 : Catalyzes the final exon ligation
(D) U6 : Binds the branch point sequence initially

2014

69. Identify the INCORRECT pair regarding post-transcriptional modifications.
(A) Poly(A) polymerase : Template-independent RNA synthesis
(B) Guanylyltransferase : Addition of GMP to the 5' end
(C) Spliceosome : Ribozyme complex for RNA editing
(D) CPSF : Cleavage and polyadenylation specificity factor

NODIA

2004

70. Analyze the following assertion and reason and select the correct option from (A) to (D).
Assertion (A): The process of alternative splicing allows a single gene to encode multiple distinct protein isoforms.
Reason (R): Alternative splicing permanently rearranges the genomic DNA sequence to create new coding frames.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

71. What is the most appropriate functional explanation for the 5' capping of eukaryotic mRNA?
(A) Signals the termination of transcription for RNA Pol II
(B) Protects mRNA from 5' exonucleases and assists initiation
(C) Provides a binding site for the prokaryotic 30S ribosome
(D) Ensures the mRNA remains permanently within the nucleus

2025

72. A failure in the function of the poly(A) binding protein (PABP) would most directly result in:

2008

52. Which statement correctly identifies a feature of rho-independent transcription termination in prokaryotes?
(A) Requires ATP-dependent helicase activity of the Rho protein
(B) Forms a GC-rich hairpin followed by a poly-U tract
(C) Relies on binding of the sigma factor to the termination sequence
(D) Occurs primarily at the initiation codon of the mRNA

2005

53. Evaluate the statements regarding the prokaryotic RNA polymerase core enzyme and identify the INCORRECT one.
(A) Consists of alpha, beta, beta prime, and omega subunits
(B) Requires the sigma factor for specific promoter recognition
(C) Catalyzes phosphodiester bonds in a 5' to 3' direction
(D) Possesses 3' to 5' proofreading activity like DNA Pol III

2021

54. Identify the correct pair involving prokaryotic promoter consensus sequences.
(A) -10 region : Pribnow box (TATAAT)
(B) -35 region : Shine-Dalgarno sequence
(C) +1 site : Transcription termination
(D) UP element : Sigma 70 binding site

2019

55. Identify the INCORRECT pair regarding prokaryotic transcription components.
(A) Beta subunit : Catalytic center for RNA synthesis
(B) Omega subunit : Promoter melting
(C) Sigma 70 : Major housekeeping factor
(D) Alpha subunit : Interaction with regulatory proteins

2009

56. All of the following are distinct phases of prokaryotic transcription EXCEPT:
(A) Promoter binding
(B) Abortive initiation
(C) 5' cap addition
(D) Elongation

2009

57. Which eukaryotic promoter element is typically positioned approximately 25 to 30 base pairs upstream of the transcription start site for RNA Polymerase II?
(A) TATA box
(B) GC box
(C) CAAT box
(D) Shine-Dalgarno sequence

2023

58. The assembly of the basal transcription machinery in eukaryotes initiates with the binding of which factor to the core promoter?
(A) TFIIA
(B) TFIIB
(C) TFIID
(D) TFIIH

2004

59. A mutation in the helicase domain of TFIIH will directly cause which functional defect in eukaryotic transcription?
(A) Fails in promoter melting and open complex formation
(B) Inability to recognize the TATA box sequence accurately
(C) Induces premature transcription termination during elongation
(D) Leads to defective 3' polyadenylation of the mRNA

2017

60. Select the correct order of general transcription factor assembly at a eukaryotic RNA Pol II promoter.
(A) TFIID → TFIIB → TFIIF/Pol II → TFIIE → TFIIH
(B) TFIIH → TFIIE → TFIID → TFIIB → TFIIF/Pol II
(C) TFIIB → TFIID → TFIIE → TFIIH → TFIIF/Pol II
(D) TFIIF/Pol II → TFIID → TFIIB → TFIIH → TFIIE

2011

61. In eukaryotic RNA Polymerase II, phosphorylation of the Carboxy-Terminal Domain (CTD) is essential for:
(A) Binding to the enhancer sequence
(B) Transitioning from initiation to processive elongation
(C) Exporting the mRNA from the nucleus
(D) Recognizing the termination signal

2017

62. Comparing prokaryotic and eukaryotic transcription, which feature is exclusively associated with eukaryotic transcription?

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(B) Synthesize DNA in a 3' to 5' direction
(C) Employ multiple origins of replication per chromosome
(D) Do not require RNA primers

2010

42. Telomerase prevents the shortening of linear eukaryotic chromosomes by utilizing which specific mechanism?
(A) Employs a DNA template to synthesize terminal chromosome ends
(B) Acts as a reverse transcriptase with an internal RNA template
(C) Ligates circular DNA ends together to ensure stability
(D) Randomly adds purine-rich repeats to the 5' DNA terminus

2017

43. Which eukaryotic DNA polymerase is primarily responsible for synthesizing the leading strand?
(A) Polymerase delta
(B) Polymerase alpha
(C) Polymerase gamma
(D) Polymerase epsilon

2009

44. Comparing eukaryotic and prokaryotic polymerases, which eukaryotic polymerase is functionally analogous to the prokaryotic DNA Pol III beta-clamp?
(A) MCM helicase
(B) PCNA (Proliferating Cell Nuclear Antigen)
(C) RFC (Replication Factor C)
(D) RPA (Replication Protein A)

2011

45. Which protein complex licenses eukaryotic origins of replication during the G_1 phase of the cell cycle?
(A) ORC (Origin Recognition Complex)
(B) Replisome
(C) TFIID
(D) Spliceosome

2009

46. Somatic cells lacking telomerase expression will undergo which of the following?
(A) Continuous unlimited proliferation
(B) Enhanced homologous recombination
(C) Immediate apoptosis during G_1
(D) Replicative senescence

2013

47. Eliminating DNA polymerase alpha from a eukaryotic cell would directly arrest replication by preventing:
(A) RNA primer synthesis and initial DNA extension
(B) Leading strand processivity
(C) Telomere elongation
(D) Okazaki fragment ligation

2016

48. What is the primary advantage of having multiple origins of replication in eukaryotic genomes?
(A) Reduces the overall mutation rate during DNA synthesis
(B) Eliminates the cellular requirement for telomerase activity
(C) Rapidly replicates exceptionally large linear genomes
(D) Prevents the formation of complex topological supercoils

2016

49. The enzyme that strictly transcribes structural RNA genes, specifically synthesizing precursor mRNA in eukaryotes, is defined as:
(A) RNA Polymerase II
(B) RNA Polymerase I
(C) RNA Polymerase III
(D) Reverse Transcriptase

NODIA

2006

50. Evaluate the following statements regarding eukaryotic RNA polymerases.
I. RNA Pol I transcribes 28S, 18S, and 5.8S rRNAs.
II. RNA Pol II transcribes mRNAs and snRNAs.
III. RNA Pol III transcribes tRNAs and 5S rRNA.
IV. RNA Pol I is highly sensitive to alpha-amanitin.
V. RNA Pol II is located in the nucleolus.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) II, III and V
(C) I, III and IV
(D) II, IV and V

2017

51. In prokaryotic transcription, the specific region of the RNA polymerase holoenzyme that recognizes the -10 and -35 promoter elements is the:
(A) Alpha subunit
(B) Sigma factor
(C) Beta subunit
(D) Omega subunit

(A) Induces unregulated transcriptional elongation by RNA Pol II
(B) Inhibits the first transesterification reaction in splicing
(C) Blocks the assembly of the RNA Polymerase III complex
(D) Decreases mRNA stability and translation efficiency

2016

73. Which feature of the genetic code explains why the sequence of amino acids remains unaffected by small variations in the third base of a codon?
(A) Non-overlapping nature
(B) Degeneracy
(C) Universality
(D) Commaless reading frame

2024

74. When evaluating the universal genetic code, which codon typically serves as the primary initiation (start) codon?
(A) AUG
(B) UAA
(C) UGA
(D) UAG

2006

75. A frameshift mutation is least impactful under which of the following conditions?
(A) Deletion of a single nucleotide within the coding region
(B) Insertion of two nucleotides near the transcription start
(C) Insertion or deletion of exactly three nucleotides
(D) Nonsense mutation occurring near the 5' end of the gene

2017

76. How does the tRNA anticodon structure adapt to genetic code degeneracy?
(A) Utilizes four nucleotides in the anticodon loop structure
(B) Completely ignores the third base of the mRNA codon sequence
(C) Employs covalent bonding to stabilize weak third-base pairings
(D) First anticodon base pairs with multiple third bases

2003

77. Which of the following is NOT one of the standard termination (stop) codons in the universal genetic code?
(A) UAA
(B) UAG
(C) UGA
(D) UGG

2025

78. What is a principal advantage of the genetic code's near-universality across different phyla?
(A) Permits transgenic DNA expression in heterologous hosts
(B) Prevents interspecies viral infections within a population
(C) Limits the mutational load in prokaryotic genome sequences
(D) Ensures that reading frames never shift during transcription

2002

79. The specific biochemical rule stating that the pairing between the 3' base of the codon and the 5' base of the anticodon is less constrained is defined as the:
(A) Central Dogma
(B) Endosymbiotic Theory
(C) Kozak Consensus
(D) Wobble Hypothesis

2004

80. Match the codon/anticodon feature in List I with its specific characteristic in List II.
List I: (Feature)
P. Start Codon
Q. Stop Codon
R. Degeneracy
S. Wobble Position
List II: (Characteristic)
1. UAA, UAG, UGA
2. 3rd base of codon / 1st base of anticodon
3. Multiple codons for one amino acid
4. AUG
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

2007

81. Which structural component of tRNA directly interacts with the mRNA codon during translation?
(A) D loop
(B) TΨC loop
(C) Anticodon loop
(D) Acceptor stem

2008

82. Which of the following supports the concept that the genetic code is "non-overlapping"?

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(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-1, R-2, S-3
(D) P-3, Q-2, R-1, S-4

2019

21. Which specific process is conventionally described by the Central Dogma of molecular biology?
(A) Direct enzymatic translation of genomic DNA into proteins
(B) Bidirectional transfer of structural templates between RNA and DNA
(C) Autonomous replication of proteins driving RNA synthesis
(D) Sequential information flow from DNA to RNA to protein

2001

22. In the topological mechanics of DNA unwinding, which enzyme relieves positive supercoiling ahead of the replication fork?
(A) DNA Helicase
(B) DNA Ligase
(C) DNA Topoisomerase II
(D) DNA Polymerase I

2003

23. Identify the correct statement regarding DNA helicase activity during replication.
(A) Synthesizes RNA primers de novo to initiate replication
(B) Covalently seals nicks in the sugar-phosphate backbone
(C) Introduces negative supercoils into the parental DNA template
(D) Uses ATP hydrolysis to disrupt hydrogen bonds between bases

2013

24. Which of the following enzymes is fundamentally classified as a Type II topoisomerase in prokaryotes?
(A) DNA Gyrase
(B) DNA Polymerase III
(C) Primase
(D) RNase H

2024

25. An inhibitor specifically targeting the ATPase domain of DNA gyrase will directly induce which effect?
(A) Immediate degradation of Okazaki fragments
(B) Accumulation of positive supercoils during replication
(C) Premature termination of translation
(D) Failure of the spliceosome assembly

2009

26. Which of the following INCORRECTLY pairs the replication enzyme with its primary topological function?
(A) Helicase : Strand separation
(B) Gyrase : Introduction of positive supercoils
(C) Topoisomerase I : Single-strand transient breaks
(D) Topoisomerase II : Double-strand transient breaks

2004

27. Identify the correct pair concerning the Central Dogma's extension via reverse transcription.
(A) RNA-dependent DNA polymerase : Retroviruses
(B) DNA-dependent RNA polymerase : Prions
(C) RNA-dependent RNA polymerase : Plasmids
(D) Protein-dependent RNA polymerase : Ribozymes

2003

28. All of the following are essential components of the prokaryotic replisome EXCEPT:
(A) DNA polymerase III
(B) DnaB helicase
(C) Telomerase
(D) Single-stranded binding proteins (SSBs)

NODIA

2023

29. What is the most appropriate description of the topological problem resolved by topoisomerases?
(A) Synthesizes RNA primers on the discontinuous lagging strand
(B) Stabilizes single-stranded DNA to prevent rapid reannealing
(C) Joins discontinuous Okazaki fragments on the lagging strand
(D) Relieves torsional strain generated by helical unwinding

2018

30. Read the following statements regarding DNA unwinding enzymes.
I. Helicase requires ATP to break hydrogen bonds.
II. Topoisomerase I requires ATP for its catalytic nicking activity.
III. DNA gyrase introduces negative supercoils.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

(C) Peptidyl-tRNA
(D) Aminoacyl-ADP

2025

92. Comparing 70S and 80S ribosomes, which RNA component is unique to the large subunit of the eukaryotic 80S ribosome?
(A) 5S rRNA
(B) 16S rRNA
(C) 23S rRNA
(D) 5.8S rRNA

2005

93. How are aminoacyl-tRNA synthetases generally grouped?
(A) Class I (monomeric) and Class II (dimeric/ multimeric)
(B) Alpha type and Beta type
(C) Prokaryotic specific and Eukaryotic specific
(D) Purine-charging and Pyrimidine-charging

2002

94. The sequence in prokaryotic mRNA that correctly positions the 30S ribosomal subunit by base-pairing with the 16S rRNA is defined as the:
(A) Pribnow box
(B) Shine-Dalgarno sequence
(C) TATA box
(D) Kozak sequence

2013

95. In prokaryotic translation initiation, which factor prevents the premature association of the 50S and 30S ribosomal subunits?
(A) IF-1
(B) IF-3
(C) IF-2
(D) EF-Tu

2005

96. Select the correct mechanism for formylmethionyl-tRNA (fMet-tRNA) binding during prokaryotic initiation.
(A) Requires the ATP-dependent binding of elongation factor EF-G
(B) Enters the A site prior to the assembly of the 50S subunit
(C) Binds independently of the specific start codon sequence
(D) Escorted to the P site by IF-2 bound to GTP

2008

97. Identify the correct statement regarding polypeptide chain elongation.
(A) Peptide bond formation is catalyzed by an RNA molecule within the ribosome.
(B) The incoming aminoacyl-tRNA directly enters the E site.
(C) Translocation occurs in the 3' to 5' direction along the mRNA.
(D) EF-Tu uses GTP to deliver tRNA to the A site.

2008

98. Identify the INCORRECT statement about prokaryotic translation termination.
(A) It requires release factors (RF_1, RF_2, RF_3).
(B) RF_1 recognizes UAA and UAG.
(C) The peptidyl transferase center shifts to hydrolyzing the ester bond of the peptidyl-tRNA.
(D) Stop codons are recognized by specific termination tRNAs.

2019

99. Identify the correct pair involving eukaryotic translation components.
(A) eIF_4E : 5' Cap binding protein
(B) eIF_2 : Translocation factor
(C) eEF_1A : Ribosome recycling factor
(D) Kozak sequence : Transcription termination

2001

100. Identify the INCORRECT pair regarding translation steps and associated energy sources.
(A) Amino acid activation : ATP
(B) tRNA delivery to A site : GTP
(C) Initiation complex assembly : GTP
(D) Ribosomal translocation : CTP

NODIA

2002

101. Which eukaryotic sequence plays a functionally analogous role to the prokaryotic Shine-Dalgarno sequence for defining the start codon context?
(A) CAAT box
(B) Kozak consensus sequence
(C) Enhancer element
(D) Polyadenylation signal

2018

102. An inhibitor that blocks the GTPase activity of Elongation Factor G (EF-G) will directly cause:
(A) Arrest of translation by preventing ribosomal translocation
(B) Enhanced fidelity in aminoacyl-tRNA selection
(C) Inability to form the initial peptide bond
(D) Premature release of the nascent polypeptide

2012

103. Which is the most appropriate description of the role of release factors in translation?
(A) Polymerizes the final amino acids of a protein sequence
(B) Mimics tRNA to bind A site and trigger hydrolysis
(C) Actively transports newly synthesized proteins to the Golgi
(D) Recycles the mRNA template back to the nucleus for reuse

2024

104. The post-translational addition of a complex oligosaccharide to the amide nitrogen of an asparagine residue is classified as:
(A) O-linked glycosylation
(B) N-linked glycosylation
(C) Proteolytic cleavage
(D) Acetylation

2001

105. Comparing phosphorylation to other post-translational modifications, which class of enzymes specifically reverses phosphorylation?
(A) Kinases
(B) Phosphatases
(C) Ligases
(D) Methyltransferases

2012

106. Which molecular components are most relevant for preventing premature folding and aggregation of nascent polypeptides?
(A) Spliceosomes
(B) Molecular chaperones
(C) Proteasomes
(D) Enhancers

2017

107. Based on the function of the GroEL/GroES complex, it relies heavily on which energetic process to refold misfolded proteins?
(A) ATP hydrolysis
(B) NADH oxidation
(C) GTP hydrolysis
(D) Proton motive force

2018

108. Which of the following is NOT a common site for post-translational phosphorylation in eukaryotes?
(A) Serine
(B) Threonine
(C) Tyrosine
(D) Glycine

2004

109. What is the primary functional advantage of post-translational proteolytic cleavage, such as the conversion of proinsulin to insulin?
(A) Permanently tags the protein for proteasomal ubiquitination
(B) Allows rapid activation of an inactive precursor
(C) Reverses amino acid stereochemistry to the D-form in proteins
(D) Prevents the protein from entering the secretory pathway

2006

110. The fundamental genetic control mechanism characterized by a repressor protein preventing transcription when bound to an operator is defined as:
(A) Positive regulation
(B) Negative regulation
(C) Attenuation
(D) Feedback inhibition

2009

111. In the context of the lac operon, which molecule specifically binds to the repressor to induce transcription?
(A) Glucose
(B) Allolactose
(C) Galactose
(D) Cyclic AMP

2014

112. In the mechanism of catabolite repression in the lac operon, high levels of glucose directly result in:
(A) Increased synthesis of cAMP within the bacterial cell
(B) Tight binding of the lac repressor to the operator sequence
(C) Decreased cAMP levels and CAP dissociation
(D) Immediate termination of transcription via attenuation

2023

113. Which statement correctly identifies the principle of attenuation in the trp operon?
(A) Utilizes the CAP-cAMP complex to enhance transcription
(B) Forms alternative RNA hairpins based on Trp levels
(C) Abolishes transcription initiation regardless of the repressor
(D) Represents a form of positive transcriptional regulation

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2024

114. Evaluate the statements regarding the lac operon structure and identify the INCORRECT one.
(A) lacZ encodes beta-galactosidase.
(B) lacY encodes lactose permease.
(C) lacA encodes a repressor protein.
(D) The operator sequence overlaps the promoter region.

2004

115. Identify the correct pair involving elements of the trp operon.
(A) trpR : Encodes the structural enzymes for tryptophan synthesis
(B) Operator : Binding site for the active Trp repressor
(C) Leader peptide (trpL) : Encodes a highly stable structural protein
(D) Attenuator : An enhancer binding site

2005

116. Identify the INCORRECT pair regarding prokaryotic regulatory mechanisms.
(A) Inducible operon : lac operon
(B) Repressible operon : trp operon
(C) Positive control factor : CAP (Catabolite Activator Protein)
(D) Corepressor for trp : Allolactose

2011

117. All of the following are required for maximal transcription of the lac operon EXCEPT:
(A) Absence of glucose
(B) Presence of lactose
(C) High levels of cAMP
(D) Binding of the repressor to the operator

2016

118. Which molecular interaction provides the best explanation for the positive regulation of the lac operon?
(A) CAP-cAMP binding assists RNA polymerase recruitment
(B) Lactose physically pulls RNA polymerase along the DNA
(C) Glucose directly phosphorylates the lac repressor protein
(D) The operator sequence acts as an autonomous helicase

2018

119. A mutation in the trp repressor gene (trpR) that prevents it from binding tryptophan will cause:
(A) Constitutive expression subject only to attenuation
(B) Permanent repression of the trp operon transcription
(C) Complete loss of RNA polymerase binding to the promoter
(D) Conversion of the trp operon into an inducible system

2014

120. Select the correct sequence of events leading to attenuation in the trp operon when tryptophan levels are high.
(A) Translation → Region 2 covered → 3-4 hairpin forms
(B) Slow translation → Ribosome stalls → 2-3 hairpin forms
(C) Rapid translation → Ribosome stalls → 1-2 hairpin forms
(D) Trp binds RNA polymerase → Detachment → 3-4 hairpin forms

2016

121. In eukaryotic transcriptional regulation, DNA sequences that can upregulate transcription from a considerable distance and independent of orientation are called:
(A) Promoters
(B) Enhancers
(C) Silencers
(D) Operators

2012

122. Which mechanism best classifies the function of epigenetic DNA methylation in eukaryotic gene expression?
(A) Post-translational protein modification
(B) Pre-transcriptional gene silencing
(C) Translational enhancement
(D) RNA editing

NODIA

2007

123. Comparing enhancers and core promoters, which characteristic uniquely defines an enhancer?
(A) Dictates the exact start site of eukaryotic transcription
(B) Exclusively binds general factors like the TFIID complex
(C) Functions effectively downstream of the target gene
(D) Is generally a heavily methylated CpG island sequence

2014

124. Which is the least relevant factor for directly modulating epigenetic DNA methylation patterns?
(A) DNA methyltransferases (DNMTs)
(B) S-adenosyl methionine (SAM) availability

(C) Rapidly phosphorylates the CTD of RNA Polymerase II
(D) Adds the poly-A tail to the completed transcript

2010

200. Match the post-transcriptional event in List I with its defining molecular actor in List II.
List I: (Post-transcriptional Event)
P. 5' Capping
Q. 3' Polyadenylation
R. Splicing branching
S. Exon Ligation
List II: (Molecular Actor)
1. Poly(A) Polymerase
2. U5 and U6 snRNPs
3. 2'-OH of an intronic Adenosine
4. Guanylyltransferase
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-2, R-4, S-1

2005

201. Which feature prevents the genetic code from resulting in massive mutational lethality due to single-base changes?
(A) Degenerate code grouping similar amino acids/codons
(B) The strict structural rigidity of the tRNA D-loop structure
(C) The absence of any termination codons in essential genes
(D) The simultaneous transcription and translation in eukaryotes

2014

202. The structural basis of the Wobble hypothesis relies upon the formation of non-Watson-Crick base pairs, frequently involving which modified nucleotide located in the tRNA anticodon?
(A) 7-methylguanosine
(B) Inosine
(C) Pseudouridine
(D) Dihydrouridine

2022

203. Which is the most appropriate description of the Peptidyl Transferase reaction?
(A) Requires the direct hydrolysis of a GTP molecule for bonds
(B) Transesterification catalyzed by 23S/28S rRNA ribozyme
(C) Involves transfer of the amino acid from A site to P site
(D) Catalyzed by an independent, non-ribosomal cytosolic enzyme

2007

204. During prokaryotic translation initiation, the mRNA is aligned correctly on the 30S subunit primarily due to:
(A) Base pairing between the Kozak sequence and initiator tRNA
(B) 16S rRNA binding complementarily to Shine-Dalgarno
(C) The direct binding of IF-1 to the start codon sequence
(D) The poly-A tail looping around to interact with the P site

2023

205. The eukaryotic translation initiation factor eIF_4G functions fundamentally as a:
(A) Scaffold protein linking 5' cap complex to poly(A)
(B) GTPase activating protein for translation initiation
(C) Sequence-specific endonuclease involved in RNA decay
(D) Ribosomal RNA methyltransferase for subunit maturation

2021

206. Based on post-translational modifications, the addition of a ubiquitin chain to a target protein most definitively signals for:
(A) Secretion to the extracellular matrix
(B) Import into the nucleus
(C) Destruction by the 26S proteasome
(D) Incorporation into the cellular membrane

2006

207. Which of the following environmental conditions would NOT typically trigger the expression of the lac operon in E. coli?
(A) Complete absence of glucose and presence of lactose
(B) Abundant glucose and abundant lactose
(C) High levels of intracellular cAMP
(D) Binding of allolactose to the repressor

2011

208. What is a primary structural consequence of extensive DNA methylation at the promoter of a tumor suppressor gene in a mammalian cell?
(A) Recruitment of MBD proteins and chromatin silencing
(B) Unregulated over-transcription of the tumor suppressor gene
(C) Immediate deletion of the gene from the

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(C) Decapping enzymes : Removal of the 5' 7-methylguanosine cap
(D) snRNP : Core complex for RNA interference

2005

135. All of the following mechanisms can regulate the translational efficiency of eukaryotic mRNA EXCEPT:
(A) Phosphorylation of initiation factor eIF_2
(B) Methylation of CpG islands in the promoter
(C) Binding of repressor proteins to the 5' UTR
(D) Regulation by microRNAs binding to the 3' UTR

2012

136. Which cellular pathway provides the most direct mechanism for the targeted degradation of misfolded or regulatory proteins?
(A) The Ubiquitin-Proteasome system
(B) The Spliceosome pathway
(C) The RNAi pathway
(D) The Glycosylation pathway

2012

137. A drug that specifically inhibits the Dicer enzyme will most likely result in:
(A) dsRNA accumulation and loss of siRNA silencing
(B) Failure to initiate classical genomic DNA replication
(C) Complete arrest of ribosomal translocation along mRNA
(D) Immediate degradation of all cellular messenger RNA

2021

138. Which statement best categorizes Type II restriction endonucleases?
(A) Cleaves DNA at random sites far from recognition sequence
(B) Requires ATP and S-adenosylmethionine for DNA cleavage
(C) Recognizes palindromes and cleaves precisely within
(D) Possesses strictly methylase activity without nuclease

2016

139. In recombinant DNA technology, the enzyme used to covalently join the 3'-OH and 5'-phosphate ends of DNA fragments is defined as:
(A) Alkaline Phosphatase
(B) DNA Ligase
(C) Restriction Endonuclease
(D) Reverse Transcriptase

NODIA

2007

140. Match the recombinant DNA tool in List I with its specific application in List II.
List I: (Recombinant DNA Tool)
P. Alkaline Phosphatase
Q. Reverse Transcriptase
R. Polynucleotide Kinase
S. Terminal Deoxynucleotidyl Transferase
List II: (Application)
1. Adds homopolymer tails to 3' ends
2. Removes 5' phosphate to prevent self-ligation
3. Synthesizes cDNA from an RNA template
4. Adds a phosphate to the 5' end of DNA
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-4, R-3, S-1
(D) P-1, Q-3, R-4, S-2

2004

141. What is the primary biological role of restriction endonucleases in bacteria?
(A) Synthesizes essential structural proteins for the cell
(B) Assists in the replication of the bacterial chromosome
(C) Protects against bacteriophage DNA by degrading it
(D) Repairs UV-induced thymine dimers in the genomic DNA

2011

142. If a researcher wishes to prevent a linearized plasmid vector from recircularizing during a cloning experiment, which enzyme should be applied?
(A) DNA Ligase
(B) Polynucleotide Kinase
(C) Alkaline Phosphatase
(D) DNA Polymerase I

2009

143. Classify the type of cleavage generated by the restriction enzyme EcoRI ($G^{\forall} \top C$).
(A) Blunt ends
(B) 5' protruding cohesive (sticky) ends
(C) 3' protruding cohesive (sticky) ends
(D) Random non-specific fragmentation

2023

144. When comparing cosmids and standard plasmid vectors, which feature is unique to cosmids?
(A) Presence of bacteriophage lambda cos sites
(B) Presence of an origin of replication
(C) Selectable marker genes
(D) Multiple cloning sites (MCS)

antigen delivery
(D) Bovine Spongiform Encephalopathy prions for delivery

2018

182. Which of the following best describes the principle of a "marker vaccine" (DIVA - Differentiating Infected from Vaccinated Animals)?
(A) Lacks a specific antigen to distinguish vaccinated from infected
(B) Contains a fluorescent dye that marks the animal's skin
(C) It strictly requires DNA microinjection into the host
(D) It causes an identifiable scar at the injection site

2023

183. Comparing subunit and live-attenuated recombinant vaccines, a major disadvantage of subunit vaccines is that they often:
(A) Poorly immunogenic alone, requiring use of adjuvants
(B) Require complex cold-chain storage for vaccine viability
(C) Carry a high risk of reverting to virulence in the host
(D) Replicate uncontrollably within the vaccinated host animal

2007

184. Which characteristic makes naked DNA vaccines particularly promising for animal health applications?
(A) Stimulates both humoral and cellular immune responses
(B) They are notoriously unstable at room temperature for long
(C) They are composed exclusively of highly allergenic proteins
(D) They universally trigger immediate anaphylactic shock in hosts

2014

185. What is the explicit design purpose of biological containment (BSL-1 to BSL-4)?
(A) Maximize the mutational rate of recombinant organisms.
(B) Safe handling and disposal to protect people and environment
(C) Standardize the patentability of genetic sequences globally.
(D) Control the market pricing of biotechnological products.

2006

186. Using the standard classification, research involving the Ebola virus, which causes severe to fatal disease with no available vaccines, must be conducted in:
(A) Biosafety Level 1 (BSL-1)
(B) Biosafety Level 2 (BSL-2)
(C) Biosafety Level 3 (BSL-3)
(D) Biosafety Level 4 (BSL-4)

2024

187. What is a primary objective of a rigorous biological risk assessment in molecular biology research?
(A) Evaluate likelihood and consequences of exposure or release
(B) Bypass national ethical guidelines to accelerate product launch
(C) Determine the commercial viability of a recombinant protein
(D) Dictate the amino acid sequence of the recombinant product

2016

188. In the context of Intellectual Property Rights (IPR), the criteria for the patentability of a genetic sequence explicitly require that the invention is:
(A) Novel, non-obvious, and possessing industrial utility
(B) An exact replica of a natural phenomenon without human aid
(C) Available in the public domain prior to application filing
(D) Completely theoretical and not yet synthesized in a lab

2008

189. The international agreement known as TRIPS (Trade-Related Aspects of Intellectual Property Rights) fundamentally serves to:
(A) Establish minimum standards for IP among WTO members
(B) Abolish all patents on biotechnological inventions globally
(C) Mandate open-source sharing of all modified organisms
(D) Regulate strictly the biosafety levels of laboratories

2022

190. Analyze the following assertion and reason and select the correct option from (A) to (D).
Assertion (A): Merely discovering and isolating a naturally occurring gene sequence without any modification is generally excluded from

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2001

155. Evaluate the statements regarding recombinant screening techniques and identify the INCORRECT one.
(A) Antibiotic markers ensure only cells with vectors survive
(B) Blue-white screening uses lacZ' to distinguish vectors
(C) Colony hybridization uses probes to identify cloned sequences
(D) Insertional inactivation kills non-recombinant cells

2023

156. Identify the correct pair involving gene delivery methods and their typical targets.
(A) Microinjection : Mass transformation of liquid bacterial cultures
(B) Agrobacterium tumefaciens : Plant cellular transformation
(C) Electroporation : In vivo whole-organism delivery
(D) Calcium phosphate : Phage packaging

2012

157. Identify the INCORRECT pair regarding screening markers.
(A) lacZ' : Beta-lactamase synthesis
(B) AmpR : Ampicillin resistance
(C) TetR : Tetracycline resistance
(D) GFP : Green Fluorescent Protein expression

2001

158. All of the following are standard methods for targeted gene delivery into eukaryotic cells EXCEPT:
(A) Liposome-mediated transfection
(B) Viral transduction
(C) Calcium phosphate coprecipitation
(D) Heat shock of native undisturbed tissue

2015

159. What is the fundamental principle enabling the specific amplification of DNA in a Polymerase Chain Reaction (PCR)?
(A) Temperature cycling guiding denaturation and extension
(B) The continuous action of DNA topoisomerase during synthesis
(C) Use of RNA primers synthesized dynamically by primase
(D) Physical cleavage of target sequences by restriction enzymes

2015

160. Read the following statements regarding PCR primer design.
I. Primers should ideally have a GC content of 40-60%.
II. The melting temperatures (Tm) of the forward and reverse primers should differ by $>10°C$.
III. Primers must lack significant secondary structures like hairpins.
IV. Primers should avoid complementary sequences at their 3' ends to prevent primer-dimers.
Which of the above statement(s) is/are INCORRECT?
(A) II only
(B) I and IV
(C) III and IV
(D) I only

NODIA

2002

161. An application of Reverse Transcription PCR (RT-PCR) directly allows for:
(A) Amplification of unknown genomic DNA sequences in cells
(B) Exact determination of a protein's amino acid sequence
(C) Absolute quantification of cellular lipids and metabolites
(D) Converts RNA to cDNA followed by target amplification

2022

162. How does real-time quantitative PCR (qPCR) fundamentally differ from end-point standard PCR?
(A) qPCR strictly utilizes RNA polymerases for amplification
(B) Measures product accumulation in real-time via fluorescence
(C) qPCR cannot be used to quantify gene expression levels
(D) qPCR requires gel electrophoresis for final visualization

2016

2023

163. Which mathematical model accurately defines the theoretical yield of a PCR reaction after 'n' cycles, assuming 100% efficiency and an initial target copy number of 'N'?
(A) $Yield = N \times 2^n$
(B) $Yield = N \times 2n$
(C) $Yield = N \times n^2$

(C) Ten-eleven translocation (TET) enzymes
(D) Aminoacyl-tRNA synthetases

2025

125. Based on typical eukaryotic epigenetic profiles, heavy methylation of promoter CpG islands directly results in:
(A) Constitutive transcription
(B) Transcriptional silencing
(C) Enhanced alternative splicing
(D) Increased mRNA stability

2006

126. Which protein domain is NOT typically involved in specific DNA binding by eukaryotic transcription factors?
(A) Zinc finger
(B) Leucine zipper
(C) Helix-turn-helix
(D) SH2 domain

2010

127. What is the primary structural advantage of specific transcription factors utilizing modular activation and DNA-binding domains?
(A) It permanently prevents protein degradation.
(B) It allows for combinatorial control of gene expression.
(C) It confines them strictly to the cytoplasm.
(D) It enables them to replicate DNA independently.

2006

128. Eukaryotic post-transcriptional regulation via alternative splicing is fundamentally defined as:
(A) Targeted degradation of precursor mRNA by the exosome
(B) Addition of novel nucleotide sequences not encoded by DNA
(C) Simultaneous transcription of multiple genes by polymerase
(D) Diverse mRNA generation by differential exon inclusion

2018

129. Identify the correct statement regarding mRNA stability as a regulatory mechanism.
(A) mRNA stability is purely random and unregulatable by factors
(B) Length of the 3' poly(A) tail inversely correlates with life
(C) AU-rich elements target mRNA for rapid degradation
(D) Prokaryotic mRNAs are generally much more stable than others

2019

130. Analyze the following assertion and reason and select the correct option from (A) to (D).
Assertion (A): MicroRNAs (miRNAs) regulate gene expression primarily by inducing premature transcription termination.
Reason (R): miRNAs function post-transcriptionally by binding to the 3' untranslated regions (UTR) of target mRNAs.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

131. The RNA interference (RNAi) pathway depends crucially on which enzyme to cleave double-stranded RNA into short interfering RNAs (siRNAs)?
(A) RNA Polymerase II
(B) Dicer
(C) Spliceosome
(D) Reverse transcriptase

2022

132. Evaluate the statements regarding the function of the RISC complex in RNAi and identify the INCORRECT one.
(A) Incorporates a single-stranded guide RNA for target search
(B) Locates target mRNAs via complementary base pairing
(C) Utilizes Argonaute proteins for endonucleolytic cleavage
(D) Translates short RNA directly into a repressor peptide

2006

133. Identify the correct pair involving small regulatory RNAs.
(A) Dicer : RNase III family ribonuclease
(B) siRNA : Endogenously synthesized imperfectly matched hairpins
(C) miRNA : Exogenously derived perfectly matched double-stranded RNA
(D) Argonaute : RNA primase

2001

134. Identify the INCORRECT pair regarding post-transcriptional control.
(A) RNA editing : Deamination of Cytosine to Uracil
(B) Alternative splicing : Skipping of specific exons

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of protein
(D) Boiling the sample to precipitate all host proteins

2014

173. Identify the correct statement regarding Immobilized Metal Affinity Chromatography (IMAC).
(A) Purifies proteins based strictly on their molecular weight
(B) Uses metal-chelated matrices to bind His-tagged proteins
(C) Separates proteins primarily by their isoelectric point
(D) Requires the use of specific monoclonal antibodies on resin

2011

174. Evaluate the statements regarding Baculovirus expression vector systems (BEVS) and identify the INCORRECT one.
(A) They infect insect cells to produce recombinant proteins.
(B) They utilize the strong, late polyhedrin promoter element.
(C) They allow for the expression of massive quantities of protein.
(D) Completely incapable of post-translational modifications

2008

175. Identify the correct pair involving protein purification methodologies.
(A) Affinity chromatography : Specific non-covalent interactions
(B) Gel filtration : Separation by electrostatic surface charge
(C) Ion-exchange : Separation by molecular size and shape
(D) Dialysis : High-resolution separation of closely related isoforms

2001

176. Identify the INCORRECT pair regarding expression system elements.
(A) IPTG : Inducer of the lac promoter
(B) Methanol : Inducer of the AOX1 promoter in Pichia
(C) Ampicillin : Inducer of the T7 promoter
(D) Shine-Dalgarno : Ribosome binding site for prokaryotic translation

2014

177. All of the following are standard strategies to improve the solubility of a recombinant protein expressed in E. coli EXCEPT:
(A) Lowering the cultivation temperature during protein expression
(B) Co-expressing molecular chaperones to aid in protein folding
(C) Fusing the target protein to highly soluble GST or MBP tags
(D) Increasing IPTG concentration to maximize induction rate

2019

178. What is the fundamental mechanism underpinning a recombinant subunit vaccine?
(A) Presents purified immunogenic fragment to elicit response
(B) It utilizes a live, fully pathogenic organism for vaccination
(C) It injects the host with pre-formed antibodies for immunity
(D) It relies on random mutations to attenuate the target virus

2005

179. Which of the following characterizes a DNA vaccine compared to a traditional protein subunit vaccine?
(A) Delivers plasmid encoding antigen for host expression
(B) Directly administers the pathogenic organism's lipid bilayer
(C) Cannot induce a cell-mediated immune response in the host
(D) Is exclusively effective in prokaryotic host organisms

2024

180. Select the correct sequence of events following the administration of a viral vector vaccine.
(A) Vector enters → Genome expressed → Antigen presented
(B) Vector degrades → Free antigens circulate → Antibody secretion
(C) Vector replicates → Host cell lyses → Macrophages engulf
(D) Vector integrates → Dormancy → Expression during division

2008

181. In animal health, the design of a recombinant viral vector vaccine frequently utilizes which type of virus as a harmless delivery vehicle?
(A) Wild-type Rabies virus used as a delivery mechanism
(B) Highly pathogenic Avian Influenza virus for vaccination
(C) Attenuated Adenovirus or Poxvirus for

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(D) $Yield = N + 2^n$

2010

164. Based on the characteristics of Taq polymerase, what is its most critical limitation that necessitated the development of enzymes like Pfu polymerase?
(A) It denatures rapidly at temperatures exceeding 95°C
(B) It requires RNA primers instead of DNA primers for extension
(C) Lacks 3' to 5' exonuclease resulting in higher errors
(D) It synthesizes DNA exclusively in the 3' to 5' direction

2024

165. Which of the following is NOT a fundamental step in a standard 3-step PCR cycle?
(A) Denaturation
(B) Ligation
(C) Annealing
(D) Extension

2016

166. What is the primary advantage of utilizing SYBR Green dye in a qPCR assay?
(A) Differentiates between multiple target sequences in a reaction
(B) Eliminates the need for any thermal cycling during the assay
(C) Directly protects the DNA polymerase from thermal degradation
(D) Binds all dsDNA, providing a cost-effective tracking

2014

167. The parameter in qPCR defined as the cycle number at which the fluorescent signal intersects the background threshold is termed the:
(A) Ct (Threshold Cycle) or Cq value
(B) Melt curve
(C) Plateau point
(D) Baseline cycle

2014

168. In recombinant protein expression, systems designed to facilitate the rapid purification of the target protein often utilize a:
(A) Strong constitutive promoter used exclusively for induction
(B) Specific affinity tag fused to the recombinant protein
(C) Host cell devoid of all endogenous proteins for clarity
(D) Polycistronic mRNA configuration without a stop codon

NODIA

2007

169. Which classification accurately describes the T7 expression system commonly used in E. coli?
(A) Constitutive plant expression system for crop improvement
(B) Eukaryotic viral expression system for mammalian cells
(C) Inducible prokaryotic system using T7 RNA polymerase
(D) Mammalian transient transfection system for protein study

2009

170. Evaluate the following characteristics relating to eukaryotic expression systems (e.g., Pichia pastoris).
I. They cannot perform complex post-translational modifications.
II. They are capable of high-density fermentation.
III. They secrete properly folded proteins into the culture medium.
IV. They exclusively utilize the lac promoter.
V. They circumvent endotoxin contamination typical of E. coli.
Which of the above statement(s) is/are correct?
(A) II, III and V
(B) I, II and IV
(C) III, IV and V
(D) I, III and V

2010

171. A major drawback of using prokaryotic systems like E. coli for producing complex human therapeutic proteins is their inability to:
(A) Inability to perform human-like glycosylation
(B) Inability to attain rapid growth rates in culture
(C) Failure to utilize inexpensive culture media for growth
(D) Failure to maintain high plasmid copy numbers in cells

2018

172. During the downstream processing of a recombinant protein expressed as insoluble inclusion bodies, which crucial step must follow initial solubilization with a chaotropic agent?
(A) Refolding of the protein to its native conformation
(B) Immediate affinity chromatography under native conditions
(C) Proteolytic degradation of the entire batch

patentability in many jurisdictions today.
Reason (R): Patent law strictly differentiates between an unpatentable "discovery" of a natural phenomenon and a patentable human "invention."
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

191. The ethical debate surrounding the patenting of genetically modified organisms (GMOs) often highlights concerns regarding:
(A) Acceleration of basic biochemical research in universities
(B) Monopolization of resources and restriction of rights
(C) Decrease in regulatory paperwork for pharmaceutical firms
(D) Impossibility of enforcing patent laws across different states

2024

192. Which ethical framework mandates that institutional review boards evaluate the potential environmental impact prior to the open-field release of transgenic crops?
(A) Biosafety Regulatory Framework (Cartagena Protocol)
(B) The Central Dogma of molecular biology information flow
(C) The Wobble Hypothesis of codon-anticodon interaction
(D) The TRIPS Agreement regarding intellectual property rights

2011

193. The specific structural transition of B-DNA to A-DNA occurs primarily due to:
(A) Reduction in relative humidity and fiber dehydration
(B) Increase in ambient temperature above the melting point
(C) Complete methylation of all cytosine residues in DNA
(D) Physical binding of the repressor protein to an operator

2005

194. Identify the correct statement characterizing histone modifications.
(A) Acetylation of histone tails generally condenses chromatin.
(B) HATs neutralize lysine charge, relaxing chromatin
(C) Phosphorylation occurs on histone H1 and triggers apoptosis.
(D) Methylation of histones universally acts as an activator.

2001

195. Identify the INCORRECT statement regarding the mechanics of DNA topoisomerases.
(A) Type I topoisomerases alter the linking number by one.
(B) Type II topoisomerases alter the linking number by two.
(C) Both types utilize a catalytic tyrosine to form intermediates.
(D) Type I topoisomerases rely on ATP for nicking activity

2017

196. Identify the correct pair involving Okazaki fragment processing in E. coli.
(A) DNA Polymerase I : 5' to 3' exonuclease primer removal
(B) DNA Polymerase III : Excision of the initial RNA primer sequence
(C) DNA Ligase : Synthesis of the initial RNA primer sequence
(D) RNase H : Sealing the phosphodiester nick in the backbone

2025

197. Identify the INCORRECT pair regarding eukaryotic replicative polymerases.
(A) Pol alpha : Primase complex association
(B) Pol delta : High-fidelity lagging strand synthesis
(C) Pol epsilon : Leading strand synthesis
(D) Pol gamma : Primary nuclear DNA repair

2004

198. All of the following are components of a standard bacterial promoter EXCEPT:
(A) TATA-binding protein (TBP)
(B) -10 consensus sequence
(C) -35 consensus sequence
(D) UP element

2014

199. What is the precise function of the TATA-binding protein (TBP) in eukaryotic transcription?
(A) Acts as a helicase to unwind the DNA during elongation
(B) Binds minor groove, bending DNA for PIC assembly

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2004

145. Which of the following vectors is most relevant for cloning extremely large genomic DNA fragments (>300 kb)?
(A) Yeast Artificial Chromosome (YAC)
(B) Standard plasmid (e.g., pBR322)
(C) Bacteriophage lambda vector
(D) Cosmid vector

2001

146. Based on the structural properties of pBR322, the inactivation of the tetracycline resistance gene upon insertion of foreign DNA is an example of:
(A) Blue-white screening
(B) Insertional inactivation
(C) Alpha complementation
(D) Attenuation

2005

147. Which of the following is NOT an essential property of an ideal cloning vector?
(A) An origin of replication for autonomous maintenance
(B) A selectable marker for identification of host cells
(C) Molecular weight exceeding 500 kDa for stability
(D) Unique restriction sites for foreign DNA insertion

2024

148. What is the primary advantage of using a Bacterial Artificial Chromosome (BAC) over a YAC for genomic library construction?
(A) BAC clones exhibit greater stability and less chimerism
(B) BACs carry infinitely larger fragments than standard YACs
(C) BACs utilize a high copy number origin of replication
(D) BACs do not require transformation into a host organism

2017

149. The process of introducing naked exogenous DNA into competent bacterial cells via transient permeability is defined as:
(A) Conjugation
(B) Transformation
(C) Transduction
(D) Electroporation

2016

150. Read the following statements regarding electroporation.
I. It utilizes short high-voltage electrical pulses.
II. It creates transient aqueous pores in the lipid bilayer.
III. It can only be used on prokaryotic cells.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2022

151. In the context of targeted gene delivery, which technique utilizes a fine glass capillary to physically deposit DNA directly into a single cell nucleus?
(A) Lipofection
(B) Biolistics (Gene gun)
(C) Microinjection
(D) Calcium phosphate precipitation

NODIA

2015

152. A researcher employs alpha-complementation (blue-white screening). The presence of white colonies on X-gal media directly indicates:
(A) Recombinant insert disrupting beta-galactosidase
(B) Vector lacks an insert, restoring functional enzyme activity
(C) The host cell is naturally resistant to ampicillin antibiotics
(D) The X-gal substrate was oxidized by atmospheric oxygen

2013

153. Which factual statement characterizes the biolistic (gene gun) method of DNA delivery?
(A) Relies on viral envelopes to fuse with the cell membrane
(B) Chemically disrupts the cell wall using harsh alkaline soaps
(C) Requires the formation of a conjugation pilus between cells
(D) Coats DNA onto heavy microparticles accelerated into tissue

2007

154. Identify the correct statement regarding chemical transformation using calcium chloride.
(A) Calcium ions shield DNA charge to aid membrane attachment
(B) Calcium ions permanently dissolve the bacterial cell wall
(C) It is exclusively utilized for transforming intact plant cells
(D) It rapidly degrades endogenous host restriction systems

cellular chromosome
(D) Enhanced binding of transcriptional activators like Sp1 protein

2011

209. In the context of RNA interference (RNAi), the guide strand of a mature siRNA directs the RISC complex to target mRNA by:
(A) Perfect or near-perfect Watson-Crick base pairing
(B) Nonspecific electrostatic interactions with the mRNA backbone
(C) Binding directly to the translating ribosome in the cytosol
(D) Covalently crosslinking to the 5' cap structure of mRNA

2021

210. Which enzyme generates cohesive "sticky" ends that are most conducive to efficient and directional cloning?
(A) SmaI (cleaves strictly to blunt ends)
(B) BamHI (generates a 5' overhang)
(C) EcoRV (cleaves to blunt ends)
(D) S1 Nuclease (degrades single-stranded overhangs)

2015

211. Identify the correct statement describing the function of a Multiple Cloning Site (MCS) in a plasmid vector.
(A) Cluster of unique sites located within lacZ' marker
(B) It provides the essential origin of replication for plasmids.
(C) It explicitly dictates the plasmid's copy number in hosts.
(D) It synthesizes the antibiotic resistance protein for selection

2017

212. Evaluate the statements regarding targeted gene delivery methods and identify the INCORRECT one.
(A) Electroporation can be utilized for both bacterial and mammalian cells.
(B) Lipofection involves encapsulating DNA in synthetic lipid vesicles.
(C) Microinjection transforms thousands of cells simultaneously
(D) Agrobacterium-mediated transfer relies on the T-DNA segment of the Ti plasmid.

2018

213. Identify the correct pair involving standard PCR variants.
(A) RT-PCR : Amplification of synthetic RNA without intermediate DNA
(B) qPCR : Quantification of amplicons in real-time
(C) Multiplex PCR : Use of a single pair to amplify multiple loci
(D) Nested PCR : Deliberate introduction of random mutations in DNA

2013

214. Evaluate the factors influencing PCR specificity and identify the INCORRECT pair.
(A) Annealing temperature : Too low causes non-specific binding
(B) Magnesium concentration : Essential cofactor for Taq polymerase
(C) Primer length : Optimal between 5 to 8 nucleotides
(D) Extension time : Dictated by the length of the target amplicon

2005

215. All of the following are distinct advantages of using Pichia pastoris over Saccharomyces cerevisiae for recombinant protein expression EXCEPT:
(A) It possesses a highly inducible, strong AOX1 promoter.
(B) It achieves significantly higher cell densities during fermentation.
(C) It completely lacks any capability for protein glycosylation.
(D) It exhibits a reduced tendency to hyper-glycosylate secreted proteins.

2002

216. Which strategy is most relevant for ensuring the long-term stability and immunogenicity of a DNA vaccine upon administration?
(A) Formulating plasmid with liposomes or nanoparticles
(B) Lyophilizing and resuspending in concentrated hydrochloric acid
(C) Administering concurrently with potent immunosuppressants
(D) Removing the promoter region from the vaccine plasmid DNA

2001

217. A laboratory facility that requires full-body positive pressure suits, dedicated air supply, and handles invariably fatal airborne pathogens must be operating at:
(A) BSL-1
(B) BSL-2

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nascent peptides

2004

255. What is the most appropriate classification for the process whereby a signal sequence directs a nascent polypeptide to the endoplasmic reticulum?
(A) Co-translational translocation
(B) Post-translational modification
(C) Alternative splicing
(D) Ubiquitination

2016

256. Which statement most accurately defines an "operon" in prokaryotic genetics?
(A) Related genes transcribed from a promoter to polycistronic mRNA
(B) A single gene regulated by multiple distant enhancers in DNA
(C) A structural protein that actively represses transcription.
(D) A mobile genetic element capable of transposition in genome.

2024

257. An enhancer element located 50 kb away from its target promoter physically interacts with the basal transcription machinery primarily through:
(A) DNA looping mediated by architectural proteins and Mediator
(B) The continuous polymerization of actin filaments along the DNA
(C) The diffusion of small secondary messengers through nucleoplasm
(D) Direct covalent crosslinking between enhancers and promoters

2006

258. Small interfering RNAs (siRNAs) generally trigger the destruction of target mRNAs by ensuring:
(A) Perfect complementarity inducing cleavage by Argonaute
(B) Imperfect complementarity, leading to translational repression
(C) The addition of extra poly-A tails to the target sequence
(D) The permanent capping of the target mRNA for sequestration

2018

259. A classic Type II restriction endonuclease typically functions biochemically as a:
(A) Homodimer cleaving both strands of the DNA symmetrically
(B) Monomer, nicking only one strand of the DNA molecule
(C) Tetramer, utilizing RNA as a guide for specific cleavage
(D) Complex requiring ATP for cleavage at distant sequences

2019

260. Match the cloning vector in List I to its typical maximum insert capacity in List II.
List I: (Cloning Vector)
P. Standard Plasmid
Q. Bacteriophage Lambda
R. Cosmid
S. Yeast Artificial Chromosome (YAC)
List II: (Insert Capacity)
1. ~5-10 kb
2. ~10-20 kb
3. ~35-45 kb
4. >300 kb
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

NODIA

2004

261. The essential requirement for a successful PCR reaction to amplify a specific locus exponentially is the presence of:
(A) A single random primer used for non-specific amplification
(B) Two sequence-specific primers flanking target in opposite orientations
(C) A highly processive RNA polymerase for transcript generation
(D) Exonuclease enzymes to degrade non-target DNA in the reaction

2018

262. In a recombinant bacterial expression system, the inclusion of a Shine-Dalgarno sequence in the cloned insert is critical for:
(A) Efficient transcription initiation by the RNA polymerase
(B) Physical binding of 30S ribosomal subunit for initiation
(C) Directing the synthesized protein to the bacterial periplasm
(D) Inducing the lac promoter in the presence of allolactose

2011

263. When evaluating recombinant subunit vaccines, a formulation relying solely on a purified recombinant protein may require the addition of an adjuvant primarily to:

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in competition.



In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

2024

228. Which of the following mutations within a critical enzyme's active site will most definitively disrupt its structure and function?
(A) A synonymous substitution within the coding gene sequence
(B) A conservative missense mutation (e.g., Asp to Glu) in the protein
(C) Non-conservative missense mutation (Asp to Val)
(D) A silent mutation in the third position of a codon sequence

2018

229. During translation, the sequence of the anticodon loop in a tRNA specifically ensures the fidelity of:
(A) Codon recognition on the mRNA template
(B) Aminoacyl-tRNA synthetase binding to the ribosome
(C) Transcription termination
(D) Proteolytic cleavage of the nascent polypeptide

2009

230. The functional role of the 16S rRNA in the small ribosomal subunit of prokaryotes is fundamentally to:
(A) Base pair with Shine-Dalgarno to position start codon
(B) Catalyze the peptide bond formation as a central ribozyme
(C) Serve as the primary structural scaffold for all 50S proteins
(D) Hydrolyze GTP during translocation of the ribosome complex

2006

231. Which of the following events strictly marks the transition from translation initiation to elongation in prokaryotes?
(A) Factor binding followed by 50S subunit association
(B) Binding of initiation factor IF-3 to the 30S subunit
(C) The entry of the first release factor into the A site
(D) The attachment of the mRNA cap to the small subunit

2017

232. Molecular chaperones like the Hsp70 family assist newly synthesized proteins primarily by:
(A) Covalently crosslinking them to the ribosome during synthesis
(B) Randomly shuffling their disulfide bonds to reach stability
(C) Transporting them to the lysosome for targeted degradation
(D) Binding hydrophobic patches to prevent aggregation

2025

233. In the lac operon, the binding of the lac repressor to the operator sequence physically blocks:
(A) Binding and progression of RNA polymerase from promoter
(B) The translation of the lacZ mRNA into functional protein
(C) The catalytic action of beta-galactosidase on lactose
(D) The entry of lactose into the cell via the permease protein

2019

234. In eukaryotic systems, specific transcription factors characterized by a "zinc finger" motif utilize the zinc ion primarily to:
(A) Maintain structural fold for sequence-specific binding
(B) Catalyze the synthesis of RNA directly from DNA templates
(C) Bind the TATA box in place of the TBP transcription factor
(D) Chelate and degrade surrounding RNA molecules in the nucleus

2004

235. MicroRNAs (miRNAs) are initially transcribed as long primary transcripts (pri-miRNAs) that are subsequently processed in the nucleus by which complex?
(A) Drosha-DGCR8 (Microprocessor complex)
(B) Spliceosome complex
(C) Dicer enzyme
(D) RISC complex

2004

236. The term "isocaudomers" refers to restriction endonucleases that:
(A) Recognize identical sequences but cleave at different positions
(B) Distinct sequences but generate identical cohesive ends
(C) Recognize strictly methylated DNA sequences within genomes
(D) Lack any specific recognition sequence for DNA cleavage

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2008

272. What is the fundamental consequence of the universal nature of the genetic code in the context of biotechnology?
(A) Stripped human gene correctly translated by bacterial host
(B) It restricts the transfer of genes between different kingdoms.
(C) It guarantees that all organisms possess identical genomes.
(D) It prevents the occurrence of silent mutations in codons.

2021

273. The "Wobble" base pairing rules specify that a Guanine (G) in the 5' position of the tRNA anticodon can form hydrogen bonds with which bases in the 3' position of the mRNA codon?
(A) U or C
(B) A or G
(C) U or A
(D) C only

2014

274. Which of the following processes is NOT associated with the elongation phase of translation?
(A) Binding of aminoacyl-tRNA to the A site
(B) Peptide bond formation via peptidyl transferase
(C) Translocation of the ribosome along the mRNA
(D) Recognition of the Shine-Dalgarno sequence

2024

275. What is the primary function of the release factors (RF_1 and RF_2) during translation termination in prokaryotes?
(A) Recognize codon and trigger polypeptide ester hydrolysis
(B) They physically block the entry of further aminoacyl-tRNAs.
(C) They catalyze the final formation of a peptide bond in chain.
(D) They serve as chaperones for the newly released protein product.

2017

276. The coordinated regulatory system of the trp operon utilizes an inactive repressor that requires binding to which molecule to become functionally active?
(A) Tryptophan
(B) Lactose
(C) Glucose
(D) Cyclic AMP

2011

277. Which molecular interaction strictly defines epigenetic regulation via DNA methylation in mammalian genomes?
(A) Methyl group attachment at C_5 of cytosine in CpG sites
(B) The transient non-covalent binding of methyl-tRNA to promoter
(C) The methylation of the ribose sugar at the 2'-OH position.
(D) The extensive methylation of poly-A tails in mature mRNA.

2018

278. Based on the mechanism of alternative splicing, a single pre-mRNA molecule can generate:
(A) Multiple mature mRNAs encoding distinct protein isoforms
(B) Only one highly specific protein isoform per gene locus.
(C) Completely distinct structural RNA molecules lacking frames.
(D) A uniform polyprotein that is later cleaved by viral proteases.

2018

279. Which statement best categorizes the functional activity of DNA ligase in recombinant cloning?
(A) Creates phosphodiester bond using ATP or NAD+ energy
(B) It catalyzes the formation of hydrogen bonds between sticky ends.
(C) It acts as a specialized nuclease to remove mispaired bases.
(D) It synthesizes new DNA to fill in large gaps between fragments.

2018

280. Evaluate the following statements regarding cloning vectors.
I. Cosmids require in vitro packaging into phage heads.
II. Plasmids typically handle inserts up to 10-15 kb.
III. BACs are based on the E. coli F-plasmid.
IV. YACs require centromeric and telomeric sequences.
Which of the above statement(s) is/are INCORRECT?
(A) II only
(B) I and III
(C) II and IV
(D) IV only

NODIA

2001

246. Evaluate the statements regarding DNA helicases and identify the INCORRECT one.
(A) They separate the double-stranded DNA template in replication.
(B) They move unidirectionally along a single DNA strand in synthesis.
(C) They utilize the energy of ATP hydrolysis for strand separation.
(D) Solely responsible for preventing separated strands reannealing

2002

247. Identify the correct pair involving Okazaki fragments.
(A) Prokaryotic fragment size : 100-200 nucleotides
(B) Eukaryotic fragment size : 1000-2000 nucleotides
(C) Prokaryotic fragment size : 1000-2000 nucleotides
(D) Viral fragment size : 10,000 nucleotides

2013

248. Evaluate the statements regarding telomere maintenance and identify the INCORRECT pair.
(A) Telomerase : Reverse transcriptase activity for end extension
(B) T-loop : Structural protection of chromosome ends from decay
(C) Hayflick limit : Replicative senescence due to telomere loss
(D) Telomere sequence : Highly variable, non-repeating codes

2024

249. All of the following directly participate in the initiation phase of prokaryotic transcription EXCEPT:
(A) Rho factor
(B) Sigma factor
(C) RNA polymerase core enzyme
(D) The -10 and -35 promoter elements

2023

250. Analyze the following assertion and reason and select the correct option from (A) to (D).
Assertion (A): The eukaryotic RNA Polymerase II requires a complex assembly of general transcription factors to initiate transcription at the basal level.
Reason (R): Unlike the prokaryotic core enzyme, purified eukaryotic RNA Polymerase II completely lacks the intrinsic ability to recognize its core promoter sequences.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

251. Which factor strictly defines the location where eukaryotic RNA splicing occurs?
(A) The rough endoplasmic reticulum involved in protein synthesis
(B) The cytoplasm where mRNA is translated into polypeptides
(C) Nucleus, co-transcriptionally or immediately post-transcription
(D) The nucleolus where ribosomal RNA synthesis occurs in cells

NODIA

2008

252. The fundamental difference between a missense mutation and a nonsense mutation is that a nonsense mutation:
(A) Changes an amino acid to a structurally similar one in protein
(B) Converts standard amino acid codon into termination codon
(C) Alters the regulatory promoter sequence of the target gene
(D) Causes a continuous shift in the reading frame of mRNA

2009

253. What is a characteristic feature of the 3' terminus of all mature tRNAs?
(A) Contains a poly-A tail added by poly(A) polymerase enzymes
(B) Terminates with 5'-CCA-3', where the amino acid attaches
(C) Is heavily methylated to prevent degradation by exonucleases
(D) Unique sequence dictating specific amino acid to be loaded

2008

254. Which of the following mechanisms is NOT utilized by the cell to maintain high fidelity during translation?
(A) The aminoacyl-tRNA synthetase proofreading mechanism in charging
(B) The requirement for correct pairing monitored by the 16S rRNA
(C) The GTP-dependent kinetic proofreading by the EF-Tu factor
(D) Ribosomal exoribonucleolytic degradation of

2005

237. Which defining feature allows Cosmids to accommodate much larger DNA inserts (~45 kb) compared to standard plasmids?
(A) Lambda cos sites enabling in vitro packaging in heads
(B) Their exceptionally strong origins of replication for plasmids
(C) The lack of any antibiotic resistance markers for selection
(D) Their linear, rather than circular, genome topology in hosts

2023

238. In the Agrobacterium-mediated transformation of plants, which specific DNA segment is actively transferred and integrated into the host plant genome?
(A) The T-DNA (Transferred DNA) region of the Ti plasmid
(B) The entire Ti plasmid introduced into the plant nucleus
(C) The vir (virulence) region responsible for T-DNA transfer
(D) The opine catabolism genes alone for bacterial nutrition

2002

239. The design of specific primers for a PCR assay aiming to amplify a generic target sequence requires primary knowledge of:
(A) The DNA sequence flanking the target region
(B) The entire secondary structure of the resulting protein
(C) The methylation status of the genomic DNA
(D) The precise location of the TATA box

2022

240. Select the correct arrangement detailing the sequential steps of downstream processing for a secreted recombinant protein.
(A) Clarification → Primary capture → Polishing → Final formulation
(B) Cell lysis → Dialysis → Final formulation → Primary capture
(C) Primary capture → Intermediate purification → Lysis → Polishing
(D) Final formulation → Polishing → Cell harvest → Capture

2016

241. Recombinant DNA vaccines frequently utilize the human cytomegalovirus (CMV) promoter primarily because it:
(A) Strong, constitutive transcription in mammalian host cells
(B) Is highly responsive to the lac operon inducer IPTG molecule
(C) Triggers immediate apoptosis in target cells after delivery
(D) Strictly requires translation by the 70S ribosome complex

2004

242. A laboratory conducting routine diagnostic PCR on non-lethal, indigenous animal pathogens (e.g., mild strains of Salmonella) typically operates under which Biosafety Level?
(A) BSL-1
(B) BSL-2
(C) BSL-3
(D) BSL-4

2006

243. Under current TRIPS-compliant patent regimes, the concept of "prior art" implies that an invention cannot be patented if:
(A) It requires extensive laboratory equipment to produce results.
(B) It involves complex mathematical formulas for calculation.
(C) Knowledge was publicly accessible before application date
(D) It addresses a critical public health crisis in the population.

2005

244. The hyperchromic shift observed when double-stranded DNA is heated reflects an increase in:
(A) Fluorescence emission by the phosphate backbone of the DNA
(B) Absorbance at 260 nm due to base unstacking
(C) The optical density of the DNA solution in the laboratory
(D) The covalent bonding between complementary strands of DNA

2010

245. Identify the correct statement detailing eukaryotic nucleosome structure.
(A) The DNA wrapped around the nucleosome is strictly right-handed.
(B) Histone H1 forms the central core of the octamer protein complex.
(C) Nucleosomes completely prevent any form of DNA transcription.
(D) Nucleosome core consists of two copies of each core histone

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(A) Enhance immunogenicity and stimulate innate immune response
(B) Prevent the protein from denaturing at room temperature storage
(C) Solubilize the protein in aqueous buffer for administration
(D) Color the vaccine for distinct identification in the clinic

2017

264. Biosafety risk assessments strictly categorize pathogens based primarily on:
(A) Disease severity, route of transmission, and treatments
(B) Their exact molecular weight and physical size of particles
(C) Their ease of genetic manipulation in the laboratory setting
(D) The number of introns present in their genomic sequences

2014

265. Under the TRIPS agreement, the "non-obviousness" (inventive step) criterion for patenting a biotechnology process fundamentally requires that the process:
(A) Not readily deducible by a person with ordinary skill
(B) Has never been theorized in science fiction or literature
(C) Can be executed using strictly basic kitchen equipment tools
(D) Results exclusively in a commercially profitable therapeutic

2024

266. Identify the correct statement regarding DNA structural stability.
(A) GC-rich DNA regions possess lower melting temperatures (Tm) than AT-rich regions.
(B) The phosphodiester backbone carries a net positive charge.
(C) Base stacking interactions involve non-covalent van der Waals forces and dipole-dipole interactions.
(D) High salt concentrations destabilize the DNA double helix by increasing electrostatic repulsion.

2006

267. Evaluate the statements regarding chromatin remodeling and identify the INCORRECT one.
(A) It involves the physical sliding of nucleosomes.
(B) It requires the hydrolysis of ATP.
(C) It always results in the permanent eviction of the histone octamer.
(D) It can alter the spacing between adjacent nucleosomes to expose regulatory sequences.

NODIA

2003

268. Identify the correct pair involving replication machinery.
(A) DNA Ligase : Phosphodiester bond formation between Okazaki fragments
(B) RNase H : Primer synthesis
(C) Topoisomerase : Synthesis of the leading strand
(D) Primase : Removal of supercoils

2003

269. Evaluate the statements regarding eukaryotic and prokaryotic polymerases and identify the INCORRECT pair.
(A) E. coli Pol III : Eukaryotic Pol delta/epsilon equivalent for processive synthesis
(B) E. coli Primase (DnaG) : Eukaryotic Pol alpha associated primase
(C) E. coli Pol I : Eukaryotic Telomerase equivalent
(D) Beta-clamp : Eukaryotic PCNA equivalent

2008

270. Read the following statements concerning prokaryotic transcription termination.
I. Rho-dependent termination requires the ATP-dependent helicase activity of the Rho hexamer.
II. Rho-independent termination relies on a GC-rich hairpin followed by a poly-U sequence.
III. Both mechanisms rely on the specific binding of the sigma factor to the termination sequence.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2013

271. All of the following generally occur co-transcriptionally in eukaryotes EXCEPT:
(A) 5' Capping of the nascent mRNA transcript after initiation
(B) Initiation of splicing reactions by the spliceosome complex
(C) Export through the nuclear pore complex to the cytoplasm
(D) Interaction of processing enzymes with the CTD of polymerase

(C) BSL-3
(D) BSL-4

2001

218. According to standard IPR protocols, which criteria specifically prevents a purely abstract mathematical model of DNA folding from being patented?
(A) Lack of Novelty
(B) Lack of Industrial Applicability/Utility
(C) It is considered prior art
(D) It violates biosafety regulations

2002

219. The conformational transition from B-DNA to Z-DNA requires an energy input, primarily because it fundamentally entails:
(A) A shift from a right-handed to a left-handed helix
(B) Breaking every phosphodiester bond
(C) Converting all purines into pyrimidines
(D) Removing the ribose sugar ring

2025

220. The primary enzymatic complex responsible for actively repositioning nucleosomes along the DNA to expose promoter sequences is termed:
(A) A Chromatin Remodeling Complex (e.g., SWI/SNF)
(B) DNA Ligase IV
(C) Histone Deacetylase (HDAC)
(D) DNA Methyltransferase

2016

221. Which statement best categorizes the functional distinction between topoisomerase I and topoisomerase II?
(A) Topo I relieves supercoiling without ATP; Topo II needs it
(B) Topo I cuts both DNA strands; Topo II cuts one strand.
(C) Topo I is found only in prokaryotes; Topo II only in eukaryotes.
(D) Topo I functions during translation; Topo II during transcription.

2002

222. In the replisome assembly of E. coli, which protein explicitly recruits the DnaB helicase to the open complex at oriC?
(A) DnaA
(B) DnaC
(C) DnaG
(D) SSB

2001

223. Telomerase utilizes its internal RNA component strictly as a:
(A) Template for synthesis of repetitive telomeric sequences
(B) Primer for Okazaki fragments during lagging strand synthesis
(C) Ribozyme used to cleave telomeric DNA at the chromosome end
(D) Structural scaffold for the splicesome complex assembly

2021

224. Which prokaryotic RNA polymerase subunit acts fundamentally as the primary anchor for complex assembly and interacts with upstream regulatory elements?
(A) Alpha subunit
(B) Beta subunit
(C) Beta prime subunit
(D) Sigma subunit

2018

225. Select the correct characteristic of the eukaryotic RNA Polymerase III promoter.
(A) Resides internally, downstream of transcription start
(B) Consists universally of a TATA box located at the -25 region
(C) It strictly requires the Upstream Binding Factor (UBF) protein
(D) Relies on RNA Polymerase II factors for initiation complex

2014

226. What is the fundamental mechanism driving spliceosome-mediated intron removal?
(A) Two successive nucleophilic transesterification reactions
(B) Sequential proteolytic cleavages of the RNA backbone
(C) Hydrolysis of the RNA via ATP-dependent endonucleases
(D) DNA topoisomerase-mediated untangling of the RNA transcript

2003

227. The hypothesis that the third base of a codon is less constrained in its pairing with the anticodon directly explains the genetic code's:
(A) Degeneracy
(B) Near-universal distribution
(C) Lack of punctuation
(D) Triplet nature

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2022

281. An application of electroporation for transforming bacterial cells fundamentally requires cells to be prepared in a buffer that is:
(A) Free of salts to prevent severe electrical arcing in cuvette
(B) Highly conductive and rich in salts for maximum current.
(C) Saturated with calcium chloride for chemical competence.
(D) Heated to exactly 42°C prior to pulsing with electricity.

2009

282. How does real-time quantitative PCR (qPCR) achieve the absolute quantification of a target sequence?
(A) Comparing threshold cycle (Ct) against a standard curve
(B) By running the final product on a high-resolution agarose gel.
(C) By visually assessing the turbidity of the reaction tube.
(D) By utilizing radioactive isotopes incorporated during plateau.

2002

283. Which feature represents a principal advantage of utilizing eukaryotic mammalian cells (e.g., CHO cells) over yeast for therapeutic protein expression?
(A) Precise replication of human-like N-glycosylation patterns
(B) Considerably faster growth rates and less expensive media.
(C) The natural absence of all human viral contaminants in host.
(D) The ability to utilize simple constitutive bacterial promoters.

2022

284. Recombinant DNA vaccines frequently elicit a potent cytotoxic T-lymphocyte (CTL) response primarily because:
(A) Antigen synthesized intracellularly and presented on MHC I
(B) They introduce fully assembled live viral particles into host.
(C) They are formulated with massive quantities of external adjuvant.
(D) The naked DNA physically disrupts the host cell membrane.

2021

285. Which of the following practices is fundamentally incompatible with standard BSL-2 laboratory procedures?
(A) Use of a Biological Safety Cabinet for aerosol procedures.
(B) Routine decontamination of work surfaces after completion.
(C) Open-bench manipulation of lethal aerosol-transmitted agents
(D) Restricted access to the laboratory during ongoing work.

2025

286. What is the fundamental legal purpose of obtaining a patent for a biotechnological invention?
(A) Exclusive rights to exploit invention for a limited period
(B) To guarantee absolute secrecy of the sequence information.
(C) To bypass all FDA or biosafety regulations regarding testing.
(D) To claim academic authorship over the underlying natural laws.

NODIA

2025

287. Which sequence most accurately reflects the general procedural order of creating a standard recombinant plasmid?
(A) Restriction digestion → Ligation → Transformation → Screening
(B) Transformation → Ligation → Screening → Restriction digestion
(C) Ligation → Screening → Transformation → Restriction digestion
(D) Restriction digestion → Transformation → Ligation → Screening

2018

288. In the structural organization of typical eukaryotic chromatin, which region is generally highly condensed, gene-poor, and heavily methylated?
(A) Heterochromatin
(B) Euchromatin
(C) Promoters of actively transcribed genes
(D) Exonic regions of housekeeping genes

2007

289. The core enzymatic activity responsible for synthesizing the short RNA segment required to initiate Okazaki fragment synthesis is:
(A) DnaG (Primase)
(B) DNA Polymerase delta
(C) DNA Ligase

(D) Telomerase

2017

290. Evaluate the following statements regarding eukaryotic translation initiation.

I. It heavily relies on the 5' cap structure and eIF_4E.
II. The small ribosomal subunit scans the mRNA for the Kozak sequence.
III. The initiator tRNA carries N-formylmethionine.
IV. It utilizes the Shine-Dalgarno sequence for initial binding.
V. It requires ATP hydrolysis for the scanning process.

Which of the above statement(s) is/are correct?
(A) I, II and V
(B) II, III and IV
(C) I, III and V
(D) II, IV and V

2021

291. Identify the correct statement detailing eukaryotic transcriptional termination by RNA Polymerase II.
(A) Exonuclease cleavage that eventually "torpedoes" polymerase
(B) It terminates rigidly at a specific stem-loop structure in DNA.
(C) It requires the Rho hexameric protein for efficient termination.
(D) It occurs independently of the polyadenylation machinery in cells.

2025

292. In the prokaryotic genetic code, which of the following is true regarding the use of "wobble" during translation?
(A) It allows a single tRNA to recognize multiple codons for the same amino acid.
(B) It occurs at the second position of the codon-anticodon interaction.
(C) It necessitates a separate aminoacyl-tRNA synthetase for every codon.
(D) It prevents the occurrence of missense mutations in the genome.

2013

293. Identify the correct pair matching the molecular chaperone with its functional mechanism.
(A) Hsp70 : Co-translational folding binding hydrophobic patches
(B) GroEL/ES : Direct cleavage of misfolded proteins in the cytosol.
(C) SRP : Refolding of aggregated proteins during transport.
(D) Ubiquitin : Protection of proteins from proteolytic degradation.

2008

294. Evaluate the statements regarding specific gene regulation terms and identify the INCORRECT one.
(A) Constitutive expression : Unregulated, continuous transcription
(B) Inducible expression : Transcription is normally off but can be turned on
(C) Repressible expression : Transcription is normally on but can be turned off
(D) Attenuation : Pre-transcriptional blockage of RNA polymerase binding

2016

295. All of the following are typical elements used to ensure robust expression in a generic eukaryotic plasmid vector EXCEPT:
(A) A strong eukaryotic promoter (e.g., CMV) for transcription.
(B) A polyadenylation signal (e.g., SV40 polyA) for mRNA stability.
(C) A eukaryotic origin (e.g., SV40 ori) for episomal maintenance.
(D) Prokaryotic Shine-Dalgarno sequence upstream of target gene

2024

296. What is the fundamental utility of reverse transcription in recombinant DNA technology?
(A) Generates intron-free cDNA from mRNA for prokaryotic use
(B) It allows researchers to directly sequence complex proteins.
(C) It serves strictly to amplify DNA fragments without thermal cycles.
(D) It actively digests RNA to prevent experimental contamination.

2014

297. Which analytical technique leverages the absolute specificity of antigen-antibody interactions to visually confirm the presence and approximate size of a target recombinant protein?
(A) Western Blotting
(B) Southern Blotting
(C) Northern Blotting
(D) Flow Cytometry

2016

298. The utilization of USA/viral vector vaccines often faces an efficacy hurdle known as "pre-existing immunity." This occurs when:

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(A) Host's immune system neutralizes delivery vector before infection
(B) The vaccine completely fails to translate the target antigen protein.
(C) The naked DNA physically degrades in the bloodstream upon entry.
(D) The target antigen directly suppresses the host's immune response.

2014

299. The requirement for a Biosafety Level 3 (BSL-3) laboratory is most explicitly dictated by the presence of biological agents that:
(A) Agents cause lethal disease through respiratory transmission
(B) Are known not to cause any disease in healthy adult humans.
(C) Cause moderate hazards but possess widely available treatments.
(D) Are uncharacterized completely synthetic oligonucleotides in use.

2009

300. In assessing Intellectual Property Rights for a novel transgenic plant expressing an engineered pest-resistance gene, the patent explicitly protects:
(A) The fundamental concept of all agricultural pest control methods.
(B) The naturally occurring wild-type progenitor plant species.
(C) Specific engineered genetic sequence and novel creation method
(D) The genetic construct and the resulting transgenic plant.

****

NODIA

sequences, or 13-mers, forming the replication bubble.

36. (D) They are polymerized in the 3' to 5' direction.
Okazaki fragments are essential for the discontinuous synthesis of the lagging strand during DNA replication. These fragments are initiated by transient RNA primers and are eventually joined by DNA ligase to form a complete strand. Importantly, all DNA synthesis, including that of Okazaki fragments, must occur strictly in the 5-prime to 3-prime direction. Polymerization in a 3-prime to 5-prime direction is enzymatically impossible.

37. (B) DnaG : RNA primase
The replication machinery of Escherichia coli consists of several specialized proteins. DnaB functions as a helicase that unwinds the DNA, while DnaG is the primase responsible for synthesizing short RNA primers. DnaC acts as a helicase loader that brings DnaB to the origin. Single-stranded binding proteins stabilize the unwound DNA. Therefore, pairing DnaG with its function as an RNA primase is correct.

38. (C) Theta subunit : RNA primer removal
The DNA polymerase III holoenzyme is a complex multi-subunit assembly. The alpha subunit provides the polymerase activity, while the epsilon subunit performs 3-prime to 5-prime proofreading. The beta clamp ensures high processivity. Although the theta subunit is part of the core, its role is to stabilize the epsilon subunit. RNA primer removal is performed by DNA polymerase I, not by any subunit of polymerase III.

39. (D) DNA Polymerase I
In prokaryotic DNA replication, the RNA primers used to initiate synthesis must be removed and replaced with DNA. While RNase H can degrade the RNA portion of an RNA-DNA hybrid, DNA Polymerase I is the primary enzyme responsible for this task. It utilizes its unique 5-prime to 3-prime exonuclease activity to remove the primer while simultaneously synthesizing DNA to fill the gap.

40. (C) I only
Prokaryotic replication involves several specialized components. DnaA is the initiator protein that recognizes the origin, while DnaC serves as the helicase loader for DnaB. SSBs prevent the formation of secondary structures, and the beta-clamp requires a clamp loader. Since DnaC, not DnaA, is the protein designated as the helicase loader, the statement identifying DnaA as the helicase loader is incorrect.

41. (C) Employ multiple origins of replication per chromosome
Prokaryotic genomes typically consist of a single circular chromosome with one origin of replication. In contrast, eukaryotic chromosomes are much larger and linear, necessitating a different strategy. To ensure the entire genome is duplicated within the time constraints of the S phase, eukaryotes utilize hundreds or even thousands of origins of replication distributed across each individual chromosome, allowing for simultaneous synthesis.

42. (B) Acts as a reverse transcriptase with an internal RNA template
Telomerase is a specialized ribonucleoprotein complex that maintains the length of linear chromosomes in eukaryotes. It functions as a reverse transcriptase, utilizing its own intrinsic RNA component as a template to synthesize repetitive DNA sequences at the chromosomal ends. This process effectively counteracts the shortening that occurs during lagging strand synthesis, ensuring the long-term stability and integrity of the cellular genomic information.

43. (D) Polymerase epsilon
Eukaryotic DNA replication utilizes different specialized polymerases for coordinated synthesis at the replication fork. While polymerase alpha initiates synthesis with a primer and polymerase delta primarily synthesizes the lagging strand, polymerase epsilon is the principal enzyme responsible for the continuous synthesis of the leading strand. Polymerase epsilon is characterized by its high processivity and essential 3-prime to 5-prime proofreading exonuclease activity.

44. (B) PCNA (Proliferating Cell Nuclear Antigen)
In DNA replication, processivity factors are required to keep the polymerase tethered to the template. In prokaryotes, this role is filled by the beta-clamp subunit of DNA polymerase III. The functional equivalent in eukaryotes is the Proliferating Cell Nuclear Antigen. This homotrimeric protein forms a ring-shaped structure around the DNA, facilitating high-

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9. (B) Base stacking interactions
While hydrogen bonding ensures the specificity of base pairing, base stacking interactions provide the primary thermodynamic stability for the DNA double helix. These interactions involve van der Waals forces and hydrophobic effects between the hydrophobic surfaces of adjacent, planar aromatic bases. Stacking effectively minimizes the contact of the hydrophobic bases with water, significantly contributing to the overall structural integrity of the molecule.

10. (A) Both A and R are true and R is the correct explanation of A.
Z-DNA is a left-handed helix favored by sequences with alternating purines and pyrimidines. The transition from the standard B-conformation to the Z-conformation is energetically demanding. Methylation of cytosine at the C_5 position stabilizes the Z-form because the methyl groups sit in a hydrophobic environment in the Z-helix, thereby lowering the energy barrier required for this specific structural transition to occur.

11. (B) 30%
According to Chargaff's rules for double-stranded DNA, the amount of adenine equals thymine, and the amount of guanine equals cytosine. Since adenine is twenty percent, thymine must also be twenty percent, totaling forty percent for A-T pairs. The remaining sixty percent represents G-C pairs. Consequently, the percentage of cytosine is exactly half of that remainder, which is thirty percent.

12. (C) Z-DNA
Z-DNA is a left-handed helical structure that typically occurs in sequences with alternating purine and pyrimidine bases. A defining biochemical feature of this conformation is the syn glycosidic bond angle for purine residues, specifically guanine. This differs from the anti conformation found in B-DNA. Mutations or conditions preventing the syn orientation would specifically interfere with the formation of the Z-DNA helix.

13. (D) Core octameric proteins
Histones H2A, H2B, H3, and H4 are highly conserved, basic proteins that play a fundamental role in eukaryotic DNA packaging. These four proteins associate in pairs to form a hetero-octameric complex. This core octamer serves as the structural foundation around which approximately 147 base pairs of DNA are wrapped, creating the basic unit of chromatin known as the nucleosome core particle.

14. (C) Nucleosome core particles
Prokaryotic and eukaryotic cells both utilize supercoiling and topological domains to organize their genomes. However, the specific association of DNA with histone proteins to form nucleosome core particles is a unique characteristic of eukaryotes. While some archaea possess histone-like proteins, the canonical octameric nucleosome structure is the fundamental repeating unit of chromatin organization exclusively found within the nuclei of eukaryotic cells.

15. (B) Abundance of lysine and arginine residues
Histone proteins are characterized by their highly basic nature, which is essential for their interaction with the negatively charged DNA phosphate backbone. This basicity is due to a high concentration of the positively charged amino acids lysine and arginine. These residues facilitate the tight wrapping of DNA around the histone octamer, enabling the efficient compaction of the genome within the nucleus.

16. (D) Histone H1
The nucleosome core particle consists of DNA wrapped around an octamer of core histones. The DNA segment between adjacent nucleosomes is known as linker DNA. Histone H1, often referred to as the linker histone, binds to the site where DNA enters and exits the core particle. This binding stabilizes the linker DNA and promotes the folding of chromatin into higher-order structures.

17. (A) SWR1 complex
Chromatin remodeling is an ATP-dependent process that alters the accessibility of DNA within the nucleus. Various complexes serve different roles in this process. The SWR1 complex is specifically known for its ability to catalyze the exchange of the standard core histone H2A with the histone variant H2A.Z. This exchange influences gene expression, DNA repair, and the overall stability of the chromatin.

18. (C) It facilitates the accessibility of the promoter to RNA polymerase.
In eukaryotes, the packaging of DNA into dense chromatin can inhibit the binding of transcription machinery. Chromatin remodeling

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repair mechanisms characteristic of genomic DNA replication.

54. (A) -10 region : Pribnow box (TATAAT)
Prokaryotic promoters contain conserved sequences that are essential for the initiation of transcription. The -10 region, commonly referred to as the Pribnow box, has the consensus sequence TATAAT and is located upstream of the transcription start site. This AT-rich region is easily unwound, facilitating the formation of the open complex where the DNA strands are separated to allow RNA synthesis.

55. (B) Omega subunit : Promoter melting
The prokaryotic RNA polymerase holoenzyme consists of multiple subunits with specialized roles. The beta subunit houses the catalytic center, the alpha subunits interact with regulatory proteins, and sigma 70 is the primary housekeeping factor. While the omega subunit aids in enzyme assembly and stability, promoter melting is primarily facilitated by the sigma factor and the beta-prime subunit. Therefore, the omega subunit is misidentified.

56. (C) 5' cap addition
Prokaryotic transcription proceeds through three distinct phases: initiation, elongation, and termination. Initiation involves promoter binding and a period of abortive initiation before the enzyme moves into elongation. Unlike eukaryotes, prokaryotic messenger RNAs do not undergo 5-prime capping or extensive post-transcriptional processing. Translation in bacteria often begins while the mRNA is still being transcribed, reflecting the lack of nuclear compartmentalization.

57. (A) TATA box
The TATA box is a critical core promoter element found in many eukaryotic genes transcribed by RNA Polymerase II. It is typically located approximately 25 to 30 base pairs upstream of the transcription start site. This sequence is recognized by the TATA-binding protein, which is a component of the TFIID complex, and serves as the assembly point for the basal transcription machinery.

58. (C) TFIID
The initiation of eukaryotic transcription by RNA Polymerase II requires the organized assembly of general transcription factors. This process begins with the binding of the TFIID complex to the core promoter. TFIID contains the TATA-binding protein and several TBP-associated factors. This initial binding event creates a platform that recruits subsequent factors, such as TFIIB and TFIIF, and finally the RNA polymerase.

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59. (A) Fails in promoter melting and open complex formation
TFIIH is a multi-protein general transcription factor essential for the initiation of eukaryotic transcription. It possesses both kinase and helicase activities. The helicase subunits of TFIIH utilize ATP to unwind the DNA at the promoter, a process known as promoter melting. If these helicase domains are mutated or dysfunctional, the transcription machinery cannot form an open complex, effectively preventing the start of transcription.

60. (A) TFIID → TFIIB → TFIIF/Pol II → TFIIE → TFIIH
The assembly of the eukaryotic pre-initiation complex follows a specific, sequential order. First, TFIID binds to the core promoter, followed by the recruitment of TFIIB. Next, a complex of RNA Polymerase II and TFIIF joins the assembly. Finally, TFIIE and TFIIH bind to the complex. TFIIH is particularly important for its helicase and kinase activities, which are required to initiate the elongation phase.

61. (B) Transitioning from initiation to processive elongation
The carboxy-terminal domain of eukaryotic RNA Polymerase II consists of repetitive heptapeptide sequences. Phosphorylation of these residues by the kinase activity of TFIIH is a critical regulatory event. This modification triggers the release of the polymerase from the general transcription factors at the promoter, allowing it to transition from initiation to the processive elongation of the messenger RNA transcript.

62. (C) Requirement for extensive chromatin remodeling
Both prokaryotic and eukaryotic transcription involve the 5-prime to 3-prime synthesis of RNA using nucleoside triphosphates without a primer. However, eukaryotic DNA is densely packaged into nucleosomes and higher-order chromatin structures. Consequently, eukaryotic transcription exclusively requires extensive

27. (A) RNA-dependent DNA polymerase : Retroviruses
Reverse transcription is an extension of the Central Dogma where information flows from RNA back to DNA. This process is catalyzed by the enzyme RNA-dependent DNA polymerase, commonly known as reverse transcriptase. This enzyme is characteristic of retroviruses, such as HIV, which must convert their RNA genome into a double-stranded DNA intermediate for integration into the host cell's chromosomal DNA during infection.

28. (C) Telomerase
The prokaryotic replisome is a multi-protein complex that coordinates DNA replication. Key components include DNA polymerase III for synthesis, DnaB helicase for unwinding, and single-stranded binding proteins to stabilize the template. Prokaryotes typically have circular chromosomes and do not require telomerase. Telomerase is an enzyme specific to eukaryotes that maintains the ends of linear chromosomes, making it unnecessary for standard prokaryotic replication.

29. (D) Relieves torsional strain generated by helical unwinding
During DNA replication, the unwinding of the double helix by helicase causes the DNA ahead of the fork to become overwound, creating significant torsional strain. If not addressed, this strain would stop replication. Topoisomerases resolve this topological problem by creating transient nicks in the DNA backbone, allowing the strands to untwist and relieve the tension before the phosphodiester bonds are resealed.

30. (B) I and III
Enzymes involved in DNA unwinding have specific energy requirements and functions. DNA helicase utilizes ATP to break hydrogen bonds between bases, while DNA gyrase, a Type II topoisomerase, uses ATP to introduce negative supercoils. In contrast, prokaryotic Topoisomerase I is a Type I enzyme that relaxes negative supercoils by creating single-strand nicks and does not require ATP hydrolysis for its activity.

31. (B) Fragmentation of the genomic DNA
Type II topoisomerases function by creating transient double-strand breaks in the DNA backbone to resolve topological knots and supercoils. Once the DNA strands are passed through the break, the enzyme must seal the nicks. If a drug inhibits this sealing step, the double-strand breaks remain permanent. This leads to the massive fragmentation of genomic DNA, which induces cell death and apoptosis.

32. (D) Antiparallel DNA nature and strict 5' to 3' synthesis
DNA polymerase enzymes can only add nucleotides in a strict 5-prime to 3-prime direction. Because the two strands of the DNA double helix are antiparallel, only one strand can be synthesized continuously as the replication fork moves. The other strand, known as the lagging strand, must be synthesized discontinuously in short segments called Okazaki fragments to maintain the required enzymatic polarity.

33. (A) Replisome
The coordinated replication of DNA at the replication fork is carried out by a large, integrated multi-protein machine called the replisome. This complex includes DNA polymerases, helicases, primases, and other supporting proteins that work together to synthesize both the leading and lagging strands simultaneously. The replisome ensures high speed, accuracy, and processivity during the duplication of the entire cellular genome.

34. (C) 5' to 3' exonuclease activity
In Escherichia coli, both DNA Polymerase I and III possess 5-prime to 3-prime polymerase and 3-prime to 5-prime proofreading exonuclease activities. However, DNA Polymerase I is uniquely characterized by its 5-prime to 3-prime exonuclease activity. This specific function allows the enzyme to remove RNA primers from the lagging strand while simultaneously filling the resulting gaps with DNA nucleotides, ensuring a continuous DNA strand.

35. (A) DnaA binds 9-mers in oriC to unwind the 13-mer region.
Prokaryotic replication initiation is a tightly regulated process occurring at a single origin called oriC. The initiator protein, DnaA, binds to specific nine-base pair sequences known as 9-mers. This binding causes the DNA to wrap around the DnaA complex, creating tension that leads to the localized unwinding of an adjacent AT-rich region containing thirteen-base pair

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complexes utilize energy from ATP hydrolysis to slide, evict, or modify nucleosomes. This structural rearrangement is crucial because it exposes promoter sequences and other regulatory elements, thereby facilitating the binding of RNA polymerase and general transcription factors required for the initiation of gene transcription.

19. (A) Nucleosome
The fundamental repeating unit of eukaryotic chromatin organization is the nucleosome. It consists of approximately 147 base pairs of DNA wound nearly twice around a protein octamer composed of two molecules each of histones H2A, H2B, H3, and H4. This "beads-on-a-string" structure provides the first level of DNA compaction and serves as a platform for various regulatory modifications and interactions.

20. (A) P-1, Q-2, R-3, S-4
Eukaryotic DNA undergoes multiple levels of hierarchical packaging to fit within the nucleus. The DNA double helix has a diameter of 2 nanometers. When wrapped around histones, it forms the 11-nanometer nucleosome fiber. Further coiling produces the 30-nanometer solenoid fiber. During cell division, these fibers are highly condensed into the mitotic chromatid, which has a diameter of approximately 700 nanometers.

21. (D) Sequential information flow from DNA to RNA to protein
The Central Dogma of molecular biology describes the fundamental process of genetic information transfer within biological systems. It posits that information stored in the DNA sequence is first transcribed into messenger RNA. This RNA intermediate is then translated into a specific sequence of amino acids to form functional proteins. This unidirectional flow ensures the accurate expression of genetic traits in all living organisms.

22. (C) DNA Topoisomerase II
As the DNA helicase unwinds the double helix during replication, torsional strain and positive supercoiling accumulate ahead of the replication fork. DNA Topoisomerase II, specifically DNA gyrase in prokaryotes, resolves this topological problem. It introduces transient double-strand breaks in the DNA, allowing the strands to rotate and relieve the tension before resealing them, thus permitting the continuous progression of the replisome.

23. (D) Uses ATP hydrolysis to disrupt hydrogen bonds between bases
DNA helicases are motor proteins essential for replication and transcription. They bind to either single-stranded or double-stranded DNA and move along the phosphodiester backbone. By utilizing the energy derived from ATP hydrolysis, helicases physically disrupt the hydrogen bonds between complementary nitrogenous bases. This action separates the two strands of the double helix, providing the single-stranded templates necessary for DNA polymerase activity.

24. (A) DNA Gyrase
Topoisomerases are essential enzymes that manage DNA supercoiling during replication and transcription. In prokaryotes, DNA gyrase is a specialized Type II topoisomerase that introduces negative supercoils into the DNA double helix. It achieves this by creating a transient double-strand break, passing another segment of the helix through the break, and resealing it, using the energy derived from ATP hydrolysis to function.

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25. (B) Accumulation of positive supercoils during replication
DNA gyrase is a prokaryotic Type II topoisomerase that actively removes positive supercoils generated during the unwinding of the DNA helix. Since this enzyme requires energy, inhibitors targeting its ATPase domain prevent its catalytic function. Without active gyrase, positive supercoils accumulate rapidly ahead of the replication fork, creating excessive torsional strain that eventually halts the progression of the replication machinery and inhibits synthesis.

26. (B) Gyrase : Introduction of positive supercoils
DNA replication involves enzymes with specific topological functions. Helicase separates DNA strands, while topoisomerases manage supercoiling. Topoisomerase I creates single-strand breaks, and Topoisomerase II creates double-strand breaks to resolve tension. However, the role of DNA gyrase, a prokaryotic Type II topoisomerase, is to introduce negative supercoils or remove positive supercoils. Identifying it as an enzyme that introduces positive supercoils is incorrect.

speed, continuous synthesis by DNA polymerases delta and epsilon.

45. (A) ORC (Origin Recognition Complex)
Replication licensing in eukaryotes ensures that the genome is duplicated exactly once per cell cycle. This process begins in the G_1 phase when the Origin Recognition Complex binds to the DNA at potential replication origins. The ORC then recruits additional proteins, such as Cdc6 and Cdt1, which facilitate the loading of the MCM helicase, preparing the origins for activation during S phase.

46. (D) Replicative senescence
In most human somatic cells, telomerase is not expressed, leading to the progressive shortening of telomeres with each round of DNA replication. When telomeres reach a critically short length, they lose their protective function, triggering a permanent cell cycle arrest. This state is known as replicative senescence, which serves as a biological safeguard against the uncontrolled proliferation of cells with damaged DNA.

47. (A) RNA primer synthesis and initial DNA extension
DNA polymerase alpha is a unique eukaryotic enzyme that exists as a complex with primase activity. During the initiation of both leading and lagging strands, the primase subunit synthesizes a short RNA primer, which is then extended by the polymerase alpha subunit with a short segment of DNA. Without functional polymerase alpha, the cell cannot initiate the synthesis of new DNA strands.

48. (C) Rapidly replicates exceptionally large linear genomes
Eukaryotic genomes are significantly larger than prokaryotic ones and are organized into multiple linear chromosomes. If replication proceeded from only a single origin per chromosome, the process would take far too long for cellular survival. By utilizing multiple origins of replication, the cell can initiate synthesis at many locations simultaneously, allowing even massive genomes to be duplicated efficiently within a single S phase.

49. (A) RNA Polymerase II
Eukaryotes possess three specialized RNA polymerases, each responsible for transcribing specific classes of genes. RNA Polymerase II is the enzyme dedicated to transcribing all protein-coding genes into precursor messenger RNA. It also synthesizes most small nuclear RNAs and microRNAs. RNA Polymerase II is distinguished by its unique carboxy-terminal domain, which is essential for coordinating various RNA processing events during transcription.

50. (A) I, II and III
Eukaryotic cells possess three distinct types of nuclear RNA polymerases with specialized functions. RNA Polymerase I is located in the nucleolus and synthesizes large ribosomal RNAs. RNA Polymerase II transcribes all protein-coding messenger RNAs and several small nuclear RNAs. RNA Polymerase III is responsible for producing transfer RNAs and the 5S ribosomal RNA. These enzymes differ in their sensitivity to inhibitors like alpha-amanitin.

51. (B) Sigma factor
In prokaryotic transcription, the RNA polymerase core enzyme requires an additional subunit called the sigma factor for initiation. The sigma factor specifically recognizes and binds to consensus sequences located at the -10 and -35 regions of the promoter. This interaction ensures that transcription begins at the correct site and is essential for the transition from the closed to the open complex.

52. (B) Forms a GC-rich hairpin followed by a poly-U tract
Rho-independent termination, also known as intrinsic termination, occurs in prokaryotes without the need for additional protein factors. This process is driven by the formation of a stable, GC-rich hairpin structure in the newly synthesized RNA. This hairpin is immediately followed by a sequence of uracil residues. The weak hydrogen bonding between the poly-U tract and the DNA template causes the transcript to detach.

53. (D) Possesses 3' to 5' proofreading activity like DNA Pol III
The prokaryotic RNA polymerase core enzyme consists of alpha, beta, beta-prime, and omega subunits and catalyzes RNA synthesis in the 5-prime to 3-prime direction. While it requires a sigma factor for promoter recognition, it does not possess a 3-prime to 5-prime proofreading exonuclease activity similar to DNA polymerases. RNA synthesis lacks the extensive high-fidelity

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functional roles: it protects the transcript from degradation by 5-prime to 3-prime exonucleases and provides a recognition signal for the translation initiation machinery. By binding to initiation factors like eIF_4E, the cap ensures that the ribosome is correctly recruited to the mRNA for protein synthesis.

72. (D) Decreases mRNA stability and translation efficiency
The poly(A) binding protein (PABP) binds to the adenine tail at the 3-prime end of eukaryotic mRNA. PABP plays a critical role in protecting the tail from deadenylation, thereby increasing the overall stability of the messenger RNA. Additionally, PABP interacts with initiation factors at the 5-prime cap to circularize the mRNA, a conformation that significantly enhances the efficiency of translation initiation.

73. (B) Degeneracy
The genetic code is described as degenerate because most amino acids are specified by more than one codon. This redundancy typically occurs at the third position of the codon, where changes often do not alter the resulting amino acid. This feature provides a buffer against mutations, ensuring that many single-base substitutions remain silent and do not affect the primary structure of the protein.

74. (A) AUG
In the universal genetic code, the codon AUG is the primary signal for the initiation of translation. It specifies the amino acid methionine in eukaryotes and N-formylmethionine in prokaryotes. The start codon establishes the correct reading frame for the ribosome, ensuring that the entire nucleotide sequence is translated into the proper sequence of amino acids to form a functional polypeptide.

75. (C) Insertion or deletion of exactly three nucleotides
Frameshift mutations occur when the addition or removal of nucleotides shifts the triplet reading frame. This usually leads to a completely different amino acid sequence and premature termination. However, since the genetic code is based on triplets, the insertion or deletion of exactly three nucleotides results in the gain or loss of a single amino acid without disrupting the subsequent reading frame of the gene.

76. (D) First anticodon base pairs with multiple third bases
The genetic code's degeneracy is accommodated by the wobble hypothesis. According to this rule, the pairing between the third base of the codon and the first base of the tRNA anticodon is less spatially constrained. This allows a single tRNA molecule to recognize and pair with multiple different codons that specify the same amino acid, reducing the total number of tRNAs required for translation.

77. (D) UGG
Translation termination is signaled by specific stop codons that do not specify any amino acid. In the universal genetic code, there are three stop codons: UAA (ochre), UAG (amber), and UGA (opal). The codon UGG is not a termination signal; instead, it is the unique codon that specifies the amino acid tryptophan, which is incorporated into the growing polypeptide chain.

78. (A) Permits transgenic DNA expression in heterologous hosts
The near-universality of the genetic code means that nearly all organisms use the same codons to specify the same amino acids. This consistency is a cornerstone of modern biotechnology, as it allows a gene from one species, such as a human, to be accurately transcribed and translated into a functional protein when introduced into a different host organism, such as bacteria or yeast.

79. (D) Wobble Hypothesis
The Wobble Hypothesis, proposed by Francis Crick, explains the non-standard base pairing that occurs between the 3-prime base of an mRNA codon and the 5-prime base of a tRNA anticodon. This flexibility allows a single tRNA to recognize multiple codons, which accounts for the degeneracy of the genetic code. It ensures that the translation process is both efficient and robust against certain mutations.

80. (A) P-4, Q-1, R-3, S-2
The genetic code possesses several defining features. The start codon is typically AUG, while the termination codons are UAA, UAG, and UGA. Degeneracy refers to the fact that multiple codons can encode a single amino acid. The wobble position specifically involves the interaction between the third base of the mRNA

chromatin remodeling to make the DNA accessible to the transcription machinery. This involves the action of ATP-dependent complexes and various histone-modifying enzymes.

63. (D) TATA-binding protein associated factors (TAFs) of RNA Pol II
RNA Polymerase I is specialized for transcribing ribosomal RNA genes. Its initiation requires specific factors, including the Upstream Binding Factor and Selectivity Factor 1, which binds to the core promoter. While both RNA Polymerase I and II utilize the TATA-binding protein, the TAFs associated with RNA Polymerase II are not involved in Polymerase I initiation, as each polymerase uses its own unique set of TAFs.

64. (D) 5' Capping
Eukaryotic messenger RNAs undergo several post-transcriptional modifications to ensure their stability and function. One of the first modifications is 5-prime capping, which involves the addition of a 7-methylguanosine residue to the first nucleotide of the transcript. This process occurs co-transcriptionally and is essential for protecting the RNA from degradation, facilitating nuclear export, and promoting the initiation of protein translation.

65. (B) 5'-5' triphosphate linkage
The 5-prime cap of eukaryotic mRNA features a unique chemical structure that is not found elsewhere in the RNA molecule. It consists of a 7-methylguanosine residue connected to the 5-prime end of the transcript through an unconventional 5-prime to 5-prime triphosphate linkage. This specific bond orientation protects the mRNA from being recognized and degraded by 5-prime exonucleases, thereby increasing its half-life.

66. (B) Cleaves pre-mRNA downstream of the AAUAAA signal
The polyadenylation of eukaryotic mRNA is a two-step process that occurs after transcription. First, the pre-mRNA is cleaved at a specific site downstream of a conserved AAUAAA signal sequence. Following this cleavage, the enzyme poly(A) polymerase adds a tail of approximately 200 adenine nucleotides to the new 3-prime end. This modification is template-independent and is crucial for mRNA stability and translation efficiency.

67. (C) Involves the 2'-OH of a conserved adenosine in the first step
RNA splicing is the process that removes non-coding introns from pre-mRNA. This reaction occurs via two sequential transesterification steps catalyzed by the spliceosome. In the first step, the 2-prime hydroxyl group of a conserved adenosine at the branch point attacks the 5-prime splice site. Identifying this as a 2-prime OH interaction is accurate; therefore, if this was labeled as incorrect, the reasoning must be carefully evaluated.

68. (A) U1 : Binds the 5' splice site
The spliceosome is composed of several small nuclear ribonucleoproteins that coordinate the removal of introns. U1 snRNP is responsible for initiating the process by binding to the 5-prime splice site via complementary base pairing. U2 then binds to the branch point sequence. Subsequent recruitment of other snRNPs leads to the formation of the catalytic complex that performs the transesterification reactions.

69. (C) Spliceosome : Ribozyme complex for RNA editing
Post-transcriptional modifications are carried out by specific enzymes and complexes. Poly(A) polymerase adds adenine tails without a template, and guanylyltransferase forms the 5-prime cap. CPSF is essential for polyadenylation signaling. However, the spliceosome is a large ribonucleoprotein complex dedicated to the removal of introns through splicing, not RNA editing. RNA editing involves the enzymatic alteration of specific nucleotide sequences within the transcript.

70. (C) A is true but R is false.
Alternative splicing is a critical mechanism in eukaryotes that allows multiple distinct protein isoforms to be produced from a single gene. While the assertion correctly describes this functional outcome, the reason is false. Alternative splicing occurs at the level of RNA processing and does not involve any permanent rearrangement or modification of the underlying genomic DNA sequence. The DNA remains unchanged throughout this process.

71. (B) Protects mRNA from 5' exonucleases and assists initiation
The 5-prime cap is a vital structural feature of eukaryotic messenger RNA. It serves two primary

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ANSWERS

1. (B) 0.34 nm
The canonical Watson-Crick B-DNA double helix is characterized by specific geometric parameters including a right-handed helical sense. The vertical distance between adjacent base pairs, known as the axial rise, is precisely 0.34 nanometers. This measurement contributes to the overall helical pitch of 3.4 nanometers per ten base pairs, defining the standard structural form of DNA in most biological organisms.

2. (C) Left-handed rotation with a zigzag sugar-phosphate backbone
Z-DNA represents a distinct conformational state of the double helix that forms under specific conditions such as high salt concentrations or torsional strain. Unlike the more common right-handed A and B forms, Z-DNA exhibits a unique left-handed helical rotation. This structure is further characterized by a characteristic zigzagging sugar-phosphate backbone, resulting from alternating purine-pyrimidine base sequences within the DNA.

3. (A) C1'
Nucleotide chemistry is defined by the specific arrangement of a pentose sugar, a nitrogenous base, and phosphate groups. The connection between the nitrogenous base and the pentose sugar occurs through a covalent N-glycosidic linkage. This bond specifically forms at the first carbon atom of the sugar ring, designated as C1-prime, ensuring the proper structural orientation of the genetic building blocks.

4. (D) Wide and compressed structure forming under dehydrated conditions
A-form DNA is a right-handed double helix that typically forms under conditions of low humidity or dehydration. Structurally, it is wider and more compressed along its helical axis compared to the standard B-form. The base pairs in A-DNA are tilted and displaced from the central axis, resulting in a deep major groove and a very shallow, wide minor groove structure.

5. (B) The ribose sugar in RNA favors a C_2'-endo conformation, exclusively forming B-form helices.
RNA differs from DNA through several key chemical features including the presence of a ribose sugar with a 2-prime hydroxyl group. In RNA, the ribose sugar predominantly adopts a C3-prime-endo pucker, which leads to the formation of A-form helices rather than B-form. This hydroxyl group also makes RNA significantly more sensitive to alkaline hydrolysis compared to the more stable deoxyribose DNA.

6. (C) Z-DNA : 1.8 nm
The three major forms of DNA exhibit distinct physical dimensions and helical properties. A-DNA is the widest form with a diameter of approximately 2.3 nanometers, while B-DNA has a standard diameter of 2.0 nanometers. Z-DNA is the narrowest conformation, possessing a diameter of approximately 1.8 nanometers. This narrow structure is associated with its unique left-handed helical sense and zigzag backbone.

7. (D) O6 of Guanine : Hydrogen bond donor
In the Watson-Crick model, complementary base pairing is stabilized by specific hydrogen bonds. Guanine pairs with cytosine using three hydrogen bonds. Within this interaction, the N_1 and N2 atoms of guanine act as hydrogen bond donors, while the O6 atom of guanine serves as a hydrogen bond acceptor. Therefore, identifying the O6 atom as a donor is chemically incorrect in this context.

8. (A) Hydrophobic interactions between phosphate groups
The stability of the DNA double helix is maintained by several forces, including hydrogen bonding between complementary bases and base stacking interactions. Covalent phosphodiester bonds form the structural backbone of each strand. However, the phosphate groups themselves are negatively charged and hydrophilic. They participate in electrostatic repulsion rather than hydrophobic interactions, requiring cations in the surrounding environment to neutralize and stabilize the structure.

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codon and the first base of the tRNA anticodon, allowing flexible pairing.

81. (C) Anticodon loop
Transfer RNA molecules serve as adapters that bridge the gap between messenger RNA and amino acids. The anticodon loop contains a specific three-nucleotide sequence that is complementary to a codon on the mRNA. During translation, the anticodon base-pairs with the codon, ensuring that the correct amino acid, which is attached to the acceptor stem, is incorporated into the growing polypeptide chain.

82. (A) Single base mutation alters only one amino acid
The genetic code is non-overlapping, meaning that each nucleotide in an mRNA sequence is part of only one codon and is read only once. This is demonstrated by the fact that a single nucleotide substitution mutation affects only a single amino acid in the resulting protein. If the code were overlapping, a single base change would simultaneously alter multiple adjacent amino acids.

83. (A) UGA codes for Tryptophan instead of acting as a stop
While the genetic code is nearly universal, several small variations exist, particularly in mitochondria. In human mitochondrial DNA, the codon UGA does not signal the termination of translation as it does in the nuclear genome. Instead, UGA is read as a codon for the amino acid tryptophan. These variations reflect the ancient and somewhat independent evolutionary history of mitochondrial genetic systems.

84. (C) Ribosomes translate all three reading frames simultaneously
Any given mRNA sequence can theoretically be read in three different reading frames. However, the ribosome only translates one specific open reading frame, which is determined by the position of the start codon. Translating multiple frames simultaneously is incorrect, as it would produce non-functional polypeptides. Frameshift mutations are detrimental precisely because they force the ribosome to shift into a different, often nonsensical, frame.

85. (D) Peptidyl transferase center : Large ribosomal subunit
Ribosomes are complex ribonucleoprotein machines where protein synthesis occurs. In both prokaryotes and eukaryotes, the catalytic site for peptide bond formation, known as the peptidyl transferase center, is located within the large ribosomal subunit. This center is composed of ribosomal RNA, making it a ribozyme. Prokaryotic cells utilize 70S ribosomes, while eukaryotic cytosolic ribosomes are 80S, each consisting of specific subunits.

86. (D) Eukaryotic small subunit : 50S
Ribosomes are composed of two subunits of unequal size. In prokaryotes, the 70S ribosome consists of a 50S large subunit and a 30S small subunit. Eukaryotic 80S ribosomes are larger, comprising a 60S large subunit and a 40S small subunit. Therefore, identifying the eukaryotic small subunit as 50S is incorrect, as 50S is specifically the large subunit found in prokaryotic cells.

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87. (D) Reliance on the ribosome for amino acid verification
Aminoacyl-tRNA synthetases ensure translational fidelity through high substrate specificity and intrinsic proofreading domains. These enzymes accurately match amino acids with their corresponding tRNAs. Once the tRNA is charged and released, the ribosome does not verify the amino acid; it only checks the codon-anticodon match. Therefore, the fidelity of protein synthesis relies heavily on the accuracy of the charging process before the tRNA reaches the ribosome.

88. (A) Double-sieve mechanism of aminoacyl-tRNA synthetases
The double-sieve mechanism is a sophisticated process used by aminoacyl-tRNA synthetases to ensure high fidelity during tRNA charging. The first sieve is the activation site, which excludes amino acids that are larger than the correct one. The second sieve is the editing site, which recognizes and hydrolyzes incorrectly activated amino acids that are smaller or similar in shape, ensuring only the correct amino acid remains.

89. (B) Misincorporation of valine in place of isoleucine
The isoleucyl-tRNA synthetase uses its editing site to distinguish between isoleucine and the

prime as the source of beta-lactamase synthesis is factually incorrect.

158. (D) Heat shock of native undisturbed tissue
Gene delivery into eukaryotic cells can be achieved through several established methods, including liposome-mediated transfection, viral transduction, and calcium phosphate coprecipitation. These techniques are designed to bypass the complex cell membrane and deliver DNA into the nucleus. However, applying a brief heat shock to native, undisturbed tissue is not a standard or effective method for gene delivery in eukaryotes, as it generally lacks the efficiency and specificity required.

159. (A) Temperature cycling guiding denaturation and extension
The Polymerase Chain Reaction is a revolutionary technique for the exponential amplification of specific DNA sequences. Its success is based on repeated cycles of temperature changes. High temperatures denature the double-stranded DNA, lower temperatures allow sequence-specific primers to anneal to the template, and an intermediate temperature permits a thermostable DNA polymerase to extend the primers. This cycling ensures that the target sequence is doubled in each round.

160. (A) II only
Effective PCR primer design is critical for the specificity and efficiency of the reaction. Primers should have a balanced GC content and lack secondary structures or complementarity at their 3-prime ends to prevent primer-dimers. Importantly, the melting temperatures of the forward and reverse primers should be very similar, ideally within one or two degrees Celsius of each other. A difference of more than ten degrees would significantly reduce the efficiency of the annealing step.

161. (D) Converts RNA to cDNA followed by target amplification
Reverse Transcription PCR is a powerful variation of the standard PCR technique used to study gene expression. It involves two sequential steps. First, the enzyme reverse transcriptase is used to synthesize a complementary DNA strand from an RNA template. Once the cDNA is formed, it serves as the template for a standard PCR reaction, allowing for the amplification and subsequent analysis of specific RNA sequences present in the original sample.

162. (B) Measures product accumulation in real-time via fluorescence
Real-time quantitative PCR, or qPCR, provides a significant advancement over standard end-point PCR. While standard PCR only allows for the analysis of products after the reaction is finished, qPCR monitors the amplification process as it occurs. This is achieved by incorporating fluorescent dyes or probes into the reaction. The increase in fluorescence is proportional to the amount of DNA being synthesized, allowing for the precise quantification of the initial template concentration.

163. (A) $Yield = N \times 2^n$
The Polymerase Chain Reaction is characterized by an exponential increase in the number of target DNA molecules. In each cycle, the two strands of every DNA molecule are separated and used as templates for new synthesis, effectively doubling the amount of DNA. Therefore, the theoretical yield after a given number of cycles can be calculated by multiplying the initial number of target copies by two raised to the power of the cycle number.

164. (C) Lacks 3' to 5' exonuclease resulting in higher errors
Taq polymerase, isolated from Thermus aquaticus, was the first thermostable enzyme used for PCR. While highly efficient, it lacks a 3-prime to 5-prime proofreading exonuclease activity. This means it cannot correct misincorporated nucleotides during synthesis, leading to a relatively high error rate. This limitation led to the development of higher-fidelity enzymes like Pfu polymerase, which possess proofreading capabilities and are used when absolute sequence accuracy is required.

165. (B) Ligation
A standard PCR cycle consists of three fundamental, temperature-dependent steps. Denaturation at high temperature separates the DNA strands, annealing at a lower temperature allows primers to bind to their target sequences, and extension at an intermediate temperature permits the DNA polymerase to synthesize new strands. Ligation is not a step in the PCR process; instead, it is a separate enzymatic reaction

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sense codons, stop codons are not recognized by tRNA molecules. Instead, they are recognized by protein release factors, such as RF_1 and RF_2. These factors trigger the peptidyl transferase center to hydrolyze the bond between the completed polypeptide and the tRNA in the P site, leading to the release of the protein.

99. (A) eIF_4E : 5' Cap binding protein
Eukaryotic translation initiation involves a variety of specialized factors. eIF_4E is the specific protein that recognizes and binds to the 7-methylguanosine cap at the 5-prime end of the mRNA. This binding is the first step in recruiting the 40S ribosomal subunit. Other factors, such as eIF_2, are involved in delivering the initiator tRNA, while the Kozak sequence provides the sequence context for identifying the start codon.

100. (D) Ribosomal translocation : CTP
Translation is a highly energy-intensive process requiring the hydrolysis of specific nucleoside triphosphates at different stages. While amino acid activation utilizes ATP, both the assembly of the initiation complex and the delivery of charged tRNAs to the ribosomal A site require GTP. Crucially, the translocation of the ribosome along the mRNA template is also powered by GTP hydrolysis, not by cytidine triphosphate.

101. (B) Kozak consensus sequence
In eukaryotes, the initiation of translation does not rely on a Shine-Dalgarno sequence. Instead, the 40S ribosomal subunit binds to the 5-prime cap and scans the mRNA for the first start codon. The efficiency of this process is significantly influenced by the surrounding nucleotides, known as the Kozak consensus sequence. This sequence correctly positions the ribosome, serving a role analogous to the Shine-Dalgarno sequence in prokaryotes.

102. (A) Arrest of translation by preventing ribosomal translocation
Elongation Factor G is a GTPase essential for the translocation step of translation in prokaryotes. After a peptide bond is formed, EF-G utilizes the energy from GTP hydrolysis to move the ribosome one codon along the mRNA. This movement shifts the tRNAs from the A and P sites to the P and E sites. Inhibiting the GTPase activity of EF-G prevents this translocation, thereby halting protein synthesis.

103. (B) Mimics tRNA to bind A site and trigger hydrolysis
Release factors are proteins that play a crucial role in terminating translation. These factors have a molecular shape that mimics a tRNA molecule, allowing them to enter the ribosomal A site when a stop codon is present. Once bound, release factors interact with the peptidyl transferase center, stimulating it to use water instead of an amino acid to hydrolyze the ester bond of the peptidyl-tRNA.

104. (B) N-linked glycosylation
Glycosylation is a common post-translational modification where carbohydrate groups are added to proteins. N-linked glycosylation specifically involves the attachment of a complex oligosaccharide to the nitrogen atom of the amide group in an asparagine residue. This process typically occurs co-transcriptionally in the endoplasmic reticulum and is essential for proper protein folding, stability, and cell signaling in eukaryotic organisms.

105. (B) Phosphatases
Protein phosphorylation is a reversible regulatory modification that alters protein function. Kinases are enzymes that catalyze the addition of a phosphate group, usually from ATP, to specific amino acid residues. This process is reversed by phosphatases, which catalyze the removal of the phosphate group through hydrolysis. The dynamic balance between kinase and phosphatase activity allows the cell to rapidly control various metabolic and signaling pathways.

106. (B) Molecular chaperones
As polypeptides emerge from the ribosome, they must fold into their functional three-dimensional shapes. Molecular chaperones are specialized proteins that assist in this process by binding to exposed hydrophobic regions of nascent or unfolded proteins. This binding prevents inappropriate interactions that could lead to aggregation or misfolding. Chaperones are essential for maintaining protein homeostasis and protecting the cell from the effects of protein stress.

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107. (A) ATP hydrolysis
The GroEL/GroES complex is a well-studied chaperonin system in prokaryotes that provides an isolated environment for protein folding. This process is highly energy-dependent, requiring the

specifically in charging tRNAs with amino acids, and have no direct role in modulating DNA methylation patterns.

125. (B) Transcriptional silencing
In the eukaryotic genome, CpG islands are often found within the promoter regions of genes. The methylation status of these islands is a critical determinant of gene activity. Heavy methylation of these sites generally leads to transcriptional silencing. This occurs because methyl groups can physically block the binding of activators or attract proteins that induce a highly condensed, inactive chromatin state, thereby preventing the initiation of transcription.

126. (D) SH2 domain
Transcription factors possess specialized domains that allow them to bind to specific DNA sequences. Common motifs include zinc fingers, leucine zippers, and the helix-turn-helix structure. These domains interact with the major groove of the DNA double helix. In contrast, the SH2 domain is a protein-protein interaction motif that specifically recognizes phosphorylated tyrosine residues. It is commonly found in signaling molecules but is not used for direct DNA binding.

127. (B) It allows for combinatorial control of gene expression.
Specific transcription factors in eukaryotes often have a modular structure, consisting of independent DNA-binding and activation domains. This modularity is a significant advantage because it allows different combinations of factors to interact and regulate gene expression. Through combinatorial control, a relatively small number of transcription factors can precisely regulate thousands of genes in a cell-type-specific and developmentally regulated manner, ensuring complex biological functioning.

128. (D) Diverse mRNA generation by differential exon inclusion
Alternative splicing is a post-transcriptional process that increases the protein diversity of eukaryotic cells. During splicing, certain exons can be either included or excluded from the final mature messenger RNA transcript. This allows a single gene to encode multiple different protein isoforms with distinct functions or properties. Alternative splicing is a key regulatory mechanism that contributes significantly to the complexity and adaptability of eukaryotic organisms.

129. (C) AU-rich elements target mRNA for rapid degradation
The stability of messenger RNA is a highly regulated process that determines how much protein can be synthesized. Specific sequences, such as AU-rich elements often found in the 3-prime untranslated region, serve as signals for rapid degradation. These elements are recognized by specialized proteins that recruit exonucleases to remove the poly(A) tail and degrade the transcript. This allows the cell to quickly downregulate the expression of certain genes.

130. (D) A is false but R is true.
MicroRNAs are small, non-coding RNAs that play a crucial role in post-transcriptional gene regulation. The assertion is false because miRNAs do not typically induce premature transcription termination. Instead, as correctly stated in the reason, miRNAs function by binding to complementary sequences in the 3-prime untranslated regions of target mRNAs. This binding leads to either the degradation of the mRNA or the inhibition of its translation into protein.

131. (B) Dicer
The RNA interference pathway is an evolutionary conserved mechanism for gene silencing. It is initiated when long double-stranded RNA is introduced into or produced within the cell. The enzyme Dicer, a member of the RNase III family, recognizes these dsRNA molecules and cleaves them into short, 21 to 23 nucleotide long fragments known as short interfering RNAs. These siRNAs are kemudian incorporated into the silencing complex.

132. (D) Translates short RNA directly into a repressor peptide
The RNA-induced silencing complex is the functional unit of the RNAi pathway. It uses a single-stranded guide RNA to locate target mRNAs through complementary base pairing. Once the target is found, Argonaute proteins within the RISC complex catalyze the cleavage of the mRNA. The statement that RISC translates RNA into a peptide is incorrect, as the complex functions strictly by degrading RNA or inhibiting its translation.

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116. (D) Corepressor for trp : Allolactose
Prokaryotic regulation involves various molecules that modify the activity of repressors. The lac operon is inducible, with allolactose serving as the inducer. The trp operon is repressible, requiring a corepressor to activate its repressor protein. In the trp operon, the corepressor is tryptophan itself. Identifying allolactose as the corepressor for the trp operon is incorrect, as allolactose is specifically the inducer for the lac operon.

117. (D) Binding of the repressor to the operator
Maximal transcription of the lac operon requires two conditions: the presence of lactose and the absence of glucose. Lactose provides the inducer allolactose, which removes the repressor from the operator. The absence of glucose leads to high cAMP levels, allowing the CAP-cAMP complex to bind and enhance RNA polymerase recruitment. Conversely, the binding of the repressor to the operator specifically prevents transcription, making it the incorrect requirement for expression.

118. (A) CAP-cAMP binding assists RNA polymerase recruitment
The lac operon is subject to positive regulation mediated by the Catabolite Activator Protein and cyclic AMP. When glucose levels are low, cAMP concentrations rise, allowing the CAP-cAMP complex to bind to a specific site upstream of the promoter. This binding enhances the recruitment of RNA polymerase to the DNA, significantly increasing the rate of transcription of the structural genes for lactose metabolism.

119. (A) Constitutive expression subject only to attenuation
The trp operon is regulated by both a repressor and an attenuation mechanism. If the trpR gene is mutated so that the repressor cannot bind tryptophan, it will remain inactive and unable to bind the operator. This results in constitutive transcription from the promoter. However, the operon will still be subject to regulation by attenuation, which responds to tryptophan levels during the translation of the leader peptide sequence.

120. (A) Translation → Region 2 covered → 3-4 hairpin forms
Attenuation in the trp operon depends on the speed of the ribosome translating the leader peptide. When tryptophan levels are high, the ribosome does not stall at the tryptophan codons and quickly moves into region 2. This prevents region 2 from pairing with region 3. Consequently, region 3 pairs with region 4 to form a stable terminator hairpin, which causes RNA polymerase to detach before reaching the structural genes.

121. (B) Enhancers
Enhancers are regulatory DNA sequences that significantly increase the transcription of specific genes in eukaryotes. Unlike promoters, which are located immediately upstream of the start site, enhancers can function over long distances and can be located upstream, downstream, or even within an intron. Enhancers work by binding specific transcription factors and looping the DNA to interact with the basal transcription machinery at the promoter.

122. (B) Pre-transcriptional gene silencing
DNA methylation is a fundamental epigenetic modification in eukaryotes that typically involves the addition of a methyl group to cytosine residues. When this occurs within promoter regions, especially at CpG islands, it often leads to pre-transcriptional gene silencing. Methylation can directly inhibit the binding of transcription factors or recruit methyl-binding proteins that promote the formation of repressive, condensed chromatin, thereby preventing gene expression.

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123. (C) Functions effectively downstream of the target gene
Both enhancers and promoters are essential for eukaryotic gene regulation, but they have distinct properties. A core promoter has a fixed position and orientation relative to the transcription start site. In contrast, an enhancer is highly flexible; it can function independently of its orientation and can be located thousands of base pairs away from the gene, including at positions downstream of the coding sequence.

124. (D) Aminoacyl-tRNA synthetases
Epigenetic DNA methylation is regulated by specialized enzymes and the availability of chemical donors. DNA methyltransferases add methyl groups, while TET enzymes are involved in their removal. S-adenosyl methionine provides the necessary methyl groups for these reactions. In contrast, aminoacyl-tRNA synthetases are enzymes involved in the translation process,

hydrolysis of ATP to drive the conformational changes necessary for the binding and release of the target protein. ATP hydrolysis coordinates the cycle of the GroES cap binding to the GroEL cylinder, ensuring that the protein has sufficient time to fold correctly.

108. (D) Glycine
Phosphorylation is a key post-translational modification that typically occurs on amino acids with hydroxyl groups in their side chains. In eukaryotes, the most common sites for phosphorylation are serine, threonine, and tyrosine residues. Glycine is the simplest amino acid and lacks a functional side chain capable of accepting a phosphate group. Therefore, glycine is not a standard site for enzymatic phosphorylation in biological systems.

109. (B) Allows rapid activation of an inactive precursor
Proteolytic cleavage is a post-translational modification where a polypeptide chain is specifically broken by proteases. This process is often used to convert an inactive precursor, or zymogen, into its active functional form. For example, the cleavage of proinsulin into insulin allows the hormone to be stored in an inactive state and rapidly activated when needed, providing a precise mechanism for regulating biological activity and response times.

110. (B) Negative regulation
Genetic control mechanisms are classified based on the effect of the regulatory protein. In negative regulation, a repressor protein binds to a specific DNA sequence called the operator, which is located near the promoter. This binding physically blocks the progression or binding of RNA polymerase, thereby preventing the transcription of the associated genes. Transcription only occurs when the repressor is removed from the operator by an inducer molecule.

111. (B) Allolactose
The lac operon is an inducible system regulated by the presence of lactose. While lactose enters the cell, a small portion is converted into allolactose by the enzyme beta-galactosidase. Allolactose acts as the true inducer by binding specifically to the lac repressor protein. This binding causes a conformational change in the repressor, reducing its affinity for the operator and allowing RNA polymerase to initiate transcription.

112. (C) Decreased cAMP levels and CAP dissociation
Catabolite repression is a mechanism that ensures E. coli preferentially uses glucose over other carbon sources. High levels of glucose inhibit the enzyme adenylate cyclase, leading to a decrease in intracellular cyclic AMP levels. Since the Catabolite Activator Protein requires cAMP to bind to the lac operon promoter, low cAMP levels cause CAP to dissociate. This results in minimal transcription of the operon, even if lactose is present.

113. (B) Forms alternative RNA hairpins based on Trp levels
Attenuation is a regulatory mechanism in the tryptophan operon that relies on the close coupling of transcription and translation in prokaryotes. It involves a leader sequence in the mRNA that can form different secondary structures or hairpins. When tryptophan levels are high, the ribosome moves quickly, favoring the formation of a terminator hairpin that stops transcription. When tryptophan is low, the ribosome stalls, allowing an anti-terminator hairpin to form.

114. (C) lacA encodes a repressor protein.
The lac operon consists of structural genes and regulatory elements. lacZ encodes beta-galactosidase, while lacY encodes lactose permease. lacA encodes a transacetylase whose function is less clear. The repressor protein is encoded by a separate, constitutively expressed gene called lacI, which is located outside the operon. Therefore, identifying lacA as the gene encoding the repressor protein is factually incorrect within the context of operon structure.

115. (B) Operator : Binding site for the active Trp repressor
The tryptophan operon is a repressible system that controls the synthesis of tryptophan. The operator is the specific DNA sequence where the Trp repressor binds. Importantly, the repressor is only active when it is bound to tryptophan, which acts as a corepressor. When the active repressor-tryptophan complex binds to the operator, it blocks RNA polymerase and prevents the transcription of the structural genes required for tryptophan biosynthesis.

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133. (A) Dicer : RNase III family ribonuclease
Small regulatory RNAs are processed by specialized enzymatic machinery. Dicer is a ribonuclease in the RNase III family that cleaves long double-stranded RNA into siRNAs or miRNAs. In contrast, siRNAs are typically derived from exogenous sources and have perfect complementarity, while miRNAs are endogenously encoded and often show imperfect matching. Argonaute is a key protein component of the RISC complex, not an RNA primase enzyme.

134. (D) snRNP : Core complex for RNA interference
Post-transcriptional control involves various processes and molecular complexes. RNA editing and alternative splicing modify the mRNA sequence and structure, while decapping enzymes initiate degradation. Small nuclear ribonucleoproteins are the core components of the spliceosome, which is responsible for removing introns from pre-mRNA. They are not involved in RNA interference; the RNAi pathway instead utilizes the RNA-induced silencing complex to target and degrade specific messenger RNAs.

135. (B) Methylation of CpG islands in the promoter
Translational efficiency can be regulated through various mechanisms, including the phosphorylation of initiation factors, the binding of regulatory proteins to untranslated regions, and the action of microRNAs. However, the methylation of CpG islands in the promoter is an epigenetic modification that occurs at the DNA level. This modification primarily regulates gene expression by silencing transcription, not by directly affecting the efficiency of translation once the mRNA has been synthesized.

136. (A) The Ubiquitin-Proteasome system
The Ubiquitin-Proteasome system is the primary pathway for the selective degradation of proteins in eukaryotic cells. Proteins targeted for destruction are covalently tagged with a chain of ubiquitin molecules. This tag is recognized by the 26S proteasome, a large multi-protein complex that unfolds the protein and degrades it into short peptides. This system is essential for removing misfolded proteins and regulating the levels of various signaling proteins.

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137. (A) dsRNA accumulation and loss of siRNA silencing
The Dicer enzyme is essential for the processing of double-stranded RNA into short interfering RNAs and for the maturation of microRNAs. If Dicer function is inhibited, the cell cannot produce these small regulatory RNAs. This leads to the accumulation of unprocessed long dsRNA molecules and a complete loss of the RNA interference-mediated gene silencing. Consequently, the regulation of many target genes and the defense against viral RNAs would be compromised.

138. (C) Recognizes palindromes and cleaves precisely within
Type II restriction endonucleases are indispensable tools in molecular cloning and recombinant DNA technology. These enzymes specifically recognize short, often palindromic, DNA sequences and catalyze the cleavage of phosphodiester bonds precisely at or near those recognition sites. Unlike other types, they do not require ATP for their nuclease activity and produce consistent, predictable fragments that are ideal for subsequent ligation into vectors.

139. (B) DNA Ligase
DNA ligase is an essential enzyme used in recombinant DNA technology to join DNA fragments. It catalyzes the formation of a covalent phosphodiester bond between the 3-prime hydroxyl group of one DNA strand and the 5-prime phosphate group of another. This reaction, which requires energy from ATP or NAD+, is used to permanently seal nicks in the sugar-phosphate backbone, creating a continuous double-stranded DNA molecule.

140. (A) P-2, Q-3, R-4, S-1
Recombinant DNA technology utilizes several specialized enzymes. Alkaline phosphatase removes 5-prime phosphate groups to prevent vector self-ligation. Reverse transcriptase synthesizes complementary DNA from an RNA template. Polynucleotide kinase adds phosphate groups to the 5-prime ends of DNA molecules. Terminal deoxynucleotidyl transferase is used to add homopolymer tails, such as poly-A or poly-T, to the 3-prime ends of DNA fragments, facilitating the cloning of blunt-ended segments.

chemically similar amino acid valine. If the editing domain is inhibited, the enzyme cannot hydrolyze the incorrectly formed valyl-AMP or valyl-tRNA. This leads to the frequent misincorporation of valine into the polypeptide chain at positions where isoleucine is specified by the genetic code, resulting in the production of defective proteins.

90. (D) The 5S rRNA is transcribed by RNA Pol I within the nucleolus.
Ribosomal biogenesis in eukaryotes is a complex process involving multiple RNA polymerases. While the 45S precursor rRNA is transcribed by RNA Polymerase I in the nucleolus, the 5S rRNA is transcribed by RNA Polymerase III. Furthermore, the 5S rRNA genes are typically located outside the nucleolus. Therefore, the statement that RNA Polymerase I transcribes 5S rRNA within the nucleolus is factually incorrect.

91. (B) Aminoacyl-AMP
The charging of tRNA is a two-step enzymatic reaction. In the first step, the aminoacyl-tRNA synthetase catalyzes the reaction between an amino acid and ATP to form a highly reactive aminoacyl-adenylate intermediate, also known as aminoacyl-AMP, with the release of pyrophosphate. In the second step, the amino acid is transferred from the AMP to the 3-prime end of the tRNA, completing the charging process.

92. (D) 5.8S rRNA
Prokaryotic and eukaryotic ribosomes differ in their RNA composition. The large 50S subunit of prokaryotes contains 5S and 23S rRNAs. The large 60S subunit of eukaryotes contains 5S, 28S, and a unique 5.8S rRNA. The 16S rRNA is specific to the prokaryotic small subunit, while its eukaryotic counterpart is the 18S rRNA. Thus, the 5.8S rRNA is a distinguishing feature of the eukaryotic large subunit.

93. (A) Class I (monomeric) and Class II (dimeric/ multimeric)
Aminoacyl-tRNA synthetases are divided into two distinct classes based on their structural motifs and reaction mechanisms. Class I enzymes are generally monomeric and attach the amino acid to the 2-prime hydroxyl group of the tRNA. Class II enzymes are typically dimeric or multimeric and attach the amino acid to the 3-prime hydroxyl group. This classification reflects deep evolutionary divisions in the machinery of protein synthesis.

94. (B) Shine-Dalgarno sequence
In prokaryotic messenger RNA, the Shine-Dalgarno sequence is a conserved, purine-rich region located upstream of the start codon. This sequence is essential for the initiation of translation, as it base-pairs with a complementary sequence at the 3-prime end of the 16S rRNA. This interaction accurately positions the 30S ribosomal subunit on the mRNA, ensuring that the start codon is correctly placed in the P site.

95. (B) IF-3
Prokaryotic translation initiation is regulated by three initiation factors. IF-3 plays a critical role by binding to the 30S small ribosomal subunit. This binding prevents the 30S subunit from prematurely associating with the 50S large subunit. By maintaining the subunits in a dissociated state, IF-3 ensures that the mRNA and the initiator tRNA can correctly assemble on the 30S subunit before the full ribosome forms.

96. (D) Escorted to the P site by IF-2 bound to GTP
In prokaryotes, translation begins with the recruitment of a specialized initiator tRNA charged with N-formylmethionine. This fMet-tRNA is specifically recognized and escorted to the 30S ribosomal subunit by initiation factor IF-2, which is bound to GTP. Unlike all other tRNAs that enter the A site during elongation, the initiator tRNA is placed directly into the P site, where it base-pairs with the AUG start codon.

97. (A) Peptide bond formation is catalyzed by an RNA molecule within the ribosome.
Polypeptide chain elongation is a multi-step cycle occurring on the ribosome. Peptide bond formation is a fundamental catalytic event carried out by the peptidyl transferase center of the large ribosomal subunit. This activity is uniquely performed by the ribosomal RNA itself, making the ribosome a ribozyme. During elongation, elongation factor EF-Tu delivers aminoacyl-tRNAs to the A site, while EF-G facilitates the translocation of the ribosome.

98. (D) Stop codons are recognized by specific termination tRNAs.
Translation termination occurs when a stop codon enters the A site of the ribosome. Unlike

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treatment or physical methods that create transient permeability in the cell membrane. Once inside, the DNA can be maintained as a plasmid or integrated into the host genome, allowing for the expression of new genetic traits.

150. (A) I and II
Electroporation is a powerful physical method for introducing exogenous DNA into a wide variety of cell types, including both prokaryotes and eukaryotes. The technique involves applying brief, high-voltage electrical pulses to a cell suspension, which creates temporary aqueous pores in the phospholipid bilayer. These transient openings allow negatively charged DNA molecules to pass through the membrane and enter the cytoplasm or the nucleus.

151. (C) Microinjection
Microinjection is a direct and precise method for gene delivery into eukaryotic cells, particularly large cells like oocytes or embryos. This technique involves the use of an extremely fine glass capillary to physically inject a DNA solution directly into the nucleus or cytoplasm of a single cell under a microscope. While it is highly efficient for individual cells, its application is limited by its low throughput compared to other mass transformation methods.

152. (A) Recombinant insert disrupting beta-galactosidase
Blue-white screening is a rapid method for identifying recombinant clones. It utilizes a host strain expressing the omega-fragment of beta-galactosidase and a vector providing the alpha-fragment. When foreign DNA is inserted into the multiple cloning site, it disrupts the alpha-fragment, preventing the formation of a functional enzyme. Consequently, recombinant colonies cannot process the X-gal substrate and appear white, while non-recombinant colonies with a functional enzyme appear blue.

153. (D) Coats DNA onto heavy microparticles accelerated into tissue
The biolistic method, or gene gun, is a physical technique used for transforming cells, especially those with thick walls like plants. In this process, DNA is coated onto the surface of heavy microparticles, typically made of gold or tungsten. These microparticles are then accelerated to high velocities using compressed gas or electrical discharge. The particles penetrate the cell walls and membranes, delivering the DNA directly into the cellular interior.

154. (A) Calcium ions shield DNA charge to aid membrane attachment
Chemical transformation using calcium chloride is a standard method for introducing plasmid DNA into E. coli. The process involves treating cells with cold calcium chloride, which facilitates the binding of the negatively charged DNA to the bacterial cell surface. The divalent calcium ions act by shielding the negative charges on both the DNA and the cell membrane. A subsequent brief heat shock then induces the uptake of the DNA into the cells.

155. (D) Insertional inactivation kills non-recombinant cells
Recombinant screening techniques serve to distinguish cells that have successfully taken up a modified vector. Antibiotic markers ensure only cells with a vector survive, and blue-white screening uses lacZ to identify inserts. Colony hybridization identifies specific sequences. However, insertional inactivation does not kill non-recombinant cells; instead, it causes a detectable change in phenotype, such as the loss of an enzymatic activity or antibiotic resistance, allowing for visual or selective identification.

156. (B) Agrobacterium tumefaciens : Plant cellular transformation
Various methods are employed for gene delivery depending on the target organism. Agrobacterium tumefaciens is a naturally occurring soil bacterium used extensively for the stable transformation of plants. It utilizes its Ti plasmid to transfer a specific DNA segment, the T-DNA, into the plant genome. In contrast, microinjection is used for single cells, electroporation for various cell types in suspension, and calcium phosphate for mammalian cell transfection in culture.

157. (A) lacZ' : Beta-lactamase synthesis
Screening markers are essential for identifying recombinant organisms. AmpR and TetR genes provide resistance to ampicillin and tetracycline, respectively, while GFP allows for fluorescent visualization. The lacZ-prime gene, however, is used for blue-white screening and encodes the alpha-peptide of the enzyme beta-galactosidase. Beta-lactamase is actually the protein encoded by the AmpR gene. Therefore, identifying lacZ-

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141. (C) Protects against bacteriophage DNA by degrading it
In nature, restriction endonucleases serve as a primitive immune system for bacteria. These enzymes protect the host cell from infection by bacteriophages. When a virus injects its DNA into a bacterium, the restriction enzymes recognize specific foreign DNA sequences and cleave them, effectively neutralizing the threat. The bacterium protects its own genomic DNA from such cleavage by methylating the corresponding recognition sites using specific methylase enzymes.

142. (C) Alkaline Phosphatase
During molecular cloning, a linearized plasmid vector can often recircularize without taking up the foreign DNA insert, especially if both ends are compatible. To prevent this, researchers use alkaline phosphatase to remove the phosphate groups from the 5-prime ends of the vector DNA. Since DNA ligase requires a 5-prime phosphate to form a phosphodiester bond, the dephosphorylated vector cannot recircularize unless it ligates with an insert.

143. (B) 5' protruding cohesive (sticky) ends
EcoRI is a widely used Type II restriction enzyme that recognizes the palindromic sequence GAATTC. It cleaves the DNA between the guanine and adenine bases on each strand. Because the cleavage sites are staggered, the reaction generates short, single-stranded overhangs known as cohesive or sticky ends. In the case of EcoRI, these overhangs are 5-prime protruding ends, which can easily base-pair with complementary sequences on other DNA fragments.

144. (A) Presence of bacteriophage lambda cos sites
Cosmids are specialized hybrid cloning vectors that combine the features of plasmids and bacteriophage lambda. Like plasmids, they contain an origin of replication and selectable markers. However, their unique feature is the presence of lambda cos sites. These sequences allow the recombinant DNA to be packaged in vitro into bacteriophage heads. This packaging mechanism enables cosmids to carry much larger DNA inserts than standard plasmid vectors.

145. (A) Yeast Artificial Chromosome (YAC)
Different cloning vectors have varying capacities for foreign DNA inserts. Plasmids and bacteriophage vectors are limited to relatively small fragments. Cosmids can carry up to 45 kilobases. For exceptionally large genomic fragments exceeding 300 kilobases, Yeast Artificial Chromosomes are the most appropriate choice. YACs are designed to function like actual chromosomes within yeast cells, including centromeres, telomeres, and origins of replication, providing immense carrying capacity.

146. (B) Insertional inactivation
The plasmid pBR322 contains two antibiotic resistance genes: ampicillin and tetracycline. Many unique restriction sites are located within these genes. When a foreign DNA fragment is inserted into one of these sites, such as the BamHI site in the tetracycline resistance gene, the coding sequence is disrupted. This process, known as insertional inactivation, allows researchers to identify recombinant clones because they will lose their resistance to that specific antibiotic.

147. (C) Molecular weight exceeding 500 kDa for stability
An ideal cloning vector must possess several key properties to be useful in recombinant DNA technology. It requires an origin of replication for autonomous maintenance, selectable markers for identifying host cells, and unique restriction sites for inserting foreign DNA. However, having a very high molecular weight is not desirable; in fact, smaller vectors are generally preferred because they are easier to handle, more stable, and more efficiently transformed into host cells.

148. (A) BAC clones exhibit greater stability and less chimerism
While both Bacterial Artificial Chromosomes and Yeast Artificial Chromosomes can carry large DNA fragments, BACs are often preferred for genomic library construction. BACs are based on the E. coli F-plasmid and are maintained at a low copy number, which leads to greater structural stability of the cloned inserts. Compared to YACs, BAC clones are less likely to undergo rearrangements or exhibit chimerism, where unrelated DNA fragments join together.

149. (B) Transformation
Transformation is a fundamental technique in molecular biology that involves the introduction of naked, exogenous DNA into a host cell. In bacteria, this process typically requires making the cells "competent," often through chemical

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used to join DNA fragments in recombinant technology.

166. (D) Binds all dsDNA, providing a cost-effective tracking
SYBR Green is a widely used fluorescent dye in real-time PCR assays. Its primary advantage is its simplicity and cost-effectiveness. The dye binds non-specifically to all double-stranded DNA produced during the reaction. When bound to dsDNA, its fluorescence increases significantly, allowing for the real-time monitoring of product accumulation. However, since it is not sequence-specific, researchers must use melt curve analysis to ensure that only the desired target was amplified.

167. (A) Ct (Threshold Cycle) or Cq value
In real-time PCR, the quantification of the initial DNA template is based on the kinetics of the amplification curve. The most important parameter is the threshold cycle, also known as the Cq value. This is the specific cycle number at which the fluorescent signal increases above the background noise and intersects a predefined threshold. The Ct value is inversely proportional to the amount of target DNA present in the original sample.

168. (B) Specific affinity tag fused to the recombinant protein
Recombinant protein expression systems are often designed to simplify the subsequent purification process. A common strategy involves fusing the target protein to a specific affinity tag, such as a poly-histidine tag or glutathione S-transferase. These tags allow the protein to be selectively captured from a complex mixture of host proteins using affinity chromatography. After purification, the tag can often be removed using a specific protease to obtain the native protein.

169. (C) Inducible prokaryotic system using T7 RNA polymerase
The T7 expression system is a highly efficient and widely used method for producing recombinant proteins in E. coli. It utilizes the powerful RNA polymerase from the T7 bacteriophage, which is extremely specific for its own promoter. Typically, the T7 RNA polymerase gene is under the control of an inducible promoter like lac. When an inducer is added, the T7 polymerase is synthesized and then transcribes the target gene at exceptionally high levels.

170. (A) II, III and V
Pichia pastoris is a sophisticated eukaryotic expression system that offers several advantages for recombinant protein production. As a yeast, it is capable of performing many post-translational modifications, including proper folding and disulfide bond formation. It can be grown to very high cell densities in fermentation and can secrete proteins directly into the media. Importantly, Pichia circumvents the problem of endotoxin contamination, which is a common concern when using E. coli systems.

171. (A) Inability to perform human-like glycosylation
While E. coli is a popular host for protein expression due to its rapid growth and low cost, it has significant limitations for producing human therapeutic proteins. Prokaryotic cells lack the complex machinery required for post-translational modifications, particularly glycosylation. Many human proteins require specific carbohydrate patterns for their stability and biological activity. Since E. coli cannot perform these modifications, the resulting proteins may be inactive or cause adverse immune reactions in patients.

172. (A) Refolding of the protein to its native conformation
High-level expression of recombinant proteins in E. coli often leads to the formation of insoluble aggregates called inclusion bodies. To recover the functional protein, these inclusion bodies must first be solubilized using strong chaotropic agents like urea or guanidine hydrochloride. However, these agents also denature the protein. Therefore, the most critical subsequent step is to carefully refold the solubilized protein into its native, biologically active three-dimensional structure under controlled conditions.

173. (B) Uses metal-chelated matrices to bind His-tagged proteins
Immobilized Metal Affinity Chromatography is a powerful technique for the rapid purification of recombinant proteins. It relies on the specific interaction between certain amino acid residues, particularly histidine, and immobilized metal ions like nickel or cobalt. Proteins that have been engineered with a poly-histidine tag bind strongly to the metal-chelated matrix in the column. The target protein can then be eluted

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standards for the protection of intellectual property rights, including those related to biotechnology. As an agreement administered by the World Trade Organization, it requires member nations to provide patent protection for both products and processes in all fields of technology. TRIPS aims to harmonize IP laws globally, encouraging innovation while ensuring that rights are enforced consistently across international borders.

190. (A) Both A and R are true and R is the correct explanation of A.
In many jurisdictions, the isolation of a naturally occurring gene sequence is considered a discovery rather than an invention, and therefore cannot be patented. Patent law maintains a strict distinction between natural phenomena and man-made inventions. To obtain a patent, a researcher must demonstrate that they have created something new, such as a modified sequence or a novel application, through human ingenuity and technical intervention, rather than simply identifying something that already exists.

191. (B) Monopolization of resources and restriction of rights
The patenting of genetically modified organisms is a subject of significant ethical debate. A major concern is that such patents can lead to the monopolization of essential biological resources, such as seeds or therapeutic proteins, by a small number of corporations. Critics argue that this can restrict the rights of farmers and researchers, increase costs, and limit access to important technological advancements, particularly in developing nations where resources are already scarce.

192. (A) Biosafety Regulatory Framework (Cartagena Protocol)
The Cartagena Protocol on Biosafety is an international agreement that governs the safe transfer, handling, and use of living modified organisms. It provides an ethical and legal framework requiring that countries conduct thorough risk assessments before allowing the environmental release of transgenic crops. These assessments evaluate potential impacts on biological diversity and human health, ensuring that the benefits of biotechnology are realized without causing significant ecological harm or unintended environmental consequences.

193. (A) Reduction in relative humidity and fiber dehydration
DNA can adopt different conformations depending on its environmental conditions. The transition from the standard B-form to the A-form is primarily driven by dehydration. When the relative humidity surrounding the DNA fiber is reduced, the water molecules interacting with the DNA are partially removed. This change in hydration forces the double helix to adopt the more wide and compressed A-conformation, which is more stable under low-water conditions.

194. (B) HATs neutralize lysine charge, relaxing chromatin
Histone modifications are critical for regulating chromatin structure and gene expression. Histone acetyltransferases catalyze the addition of acetyl groups to lysine residues in histone tails. This modification neutralizes the positive charge on the lysines, weakening the electrostatic interaction between the histones and the negatively charged DNA. Consequently, the chromatin structure relaxes, becoming more accessible to the transcription machinery, which generally leads to an increase in gene expression.

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195. (D) Type I topoisomerases rely on ATP for nicking activity
Topoisomerases are classified into two types based on their catalytic mechanism. Type I enzymes create a single-strand break and do not require ATP to alter the linking number by one. Type II enzymes create a double-strand break and require ATP hydrolysis to alter the linking number by two. Both types utilize a conserved tyrosine residue to form a transient covalent intermediate with the DNA backbone, ensuring that the DNA is safely held during the process.

196. (A) DNA Polymerase I : 5' to 3' exonuclease primer removal
The processing of Okazaki fragments in E. coli requires the coordinated action of several enzymes. DNA Polymerase I plays a vital role by using its unique 5-prime to 3-prime exonuclease activity to remove the RNA primers from the lagging strand. As it removes the RNA, the enzyme also uses its polymerase activity to fill in the resulting gaps with DNA. Finally, DNA ligase seals the nicks to create a continuous strand.

a pathogen. When the vaccine is administered, the vector infects host cells and expresses the antigen, inducing a strong and specific immune response without causing disease.

182. (A) Lacks a specific antigen to distinguish vaccinated from infected
Marker vaccines, or DIVA vaccines, are critical tools for disease control and eradication programs in livestock. These vaccines are designed so that the immune response they elicit can be distinguished from the response caused by a natural infection. This is often achieved by deleting a non-essential but immunogenic protein from the vaccine strain. Serological tests can then be used to identify animals that lack antibodies to the deleted protein, indicating they were vaccinated and not infected.

183. (A) Poorly immunogenic alone, requiring use of adjuvants
While recombinant subunit vaccines are extremely safe because they do not contain live pathogens, they are often less immunogenic than whole-organism vaccines. The purified proteins may not provide the same level of stimulation to the innate immune system. To overcome this disadvantage, subunit vaccines are typically formulated with adjuvants. Adjuvants are substances that enhance and prolong the immune response to the antigen, ensuring that the vaccine provides robust and long-lasting protection.

184. (A) Stimulates both humoral and cellular immune responses
Naked DNA vaccines offer several advantages for animal health, particularly their ability to induce a comprehensive immune response. Because the antigen is synthesized within the host's own cells, it is presented via both MHC Class I and Class II pathways. This leads to the activation of both B-cells for antibody production and T-cells for cell-mediated immunity. This dual response is especially effective for protecting against intracellular pathogens and providing long-term immunological memory.

185. (B) Safe handling and disposal to protect people and environment
Biological containment is a fundamental principle in molecular biology research, designed to manage the risks associated with handling potentially hazardous organisms. The purpose of establishing Biosafety Levels 1 through 4 is to provide standardized guidelines for the safe handling, storage, and disposal of biological agents. These levels ensure that laboratory personnel are protected from exposure and that the environment is shielded from the accidental release of recombinant or pathogenic materials.

186. (D) Biosafety Level 4 (BSL-4)
Pathogens are classified into biosafety levels based on the severity of the disease they cause and the availability of treatments. The Ebola virus is an extremely dangerous pathogen that causes severe hemorrhagic fever with a high fatality rate, and for which no widely available vaccines or cures exist. Due to its high risk of aerosol transmission and lethal nature, all research involving live Ebola virus must be conducted in the highest containment facilities, Biosafety Level 4.

187. (A) Evaluate likelihood and consequences of exposure or release
Biological risk assessment is a critical process in molecular biology used to identify the hazards associated with specific research activities. The primary objective is to systematically evaluate both the likelihood of an accidental exposure or environmental release and the potential consequences of such an event. This assessment guides the selection of appropriate biosafety levels, laboratory practices, and safety equipment to mitigate the risks and ensure that the research is conducted safely.

188. (A) Novel, non-obvious, and possessing industrial utility
Intellectual property rights provide a legal framework for protecting biotechnological inventions through patents. To be patentable, a genetic sequence or process must meet three fundamental criteria: it must be novel, meaning it has not been previously disclosed; it must be non-obvious to someone skilled in the field; and it must have industrial utility, meaning it serves a practical purpose. Purely theoretical discoveries or naturally occurring phenomena without human modification are generally excluded from patent protection.

189. (A) Establish minimum standards for IP among WTO members
The TRIPS Agreement is a significant international treaty that sets out minimum

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other regulatory elements that were previously hidden, allowing the transcription machinery to bind and initiate gene expression. This process is vital for cellular differentiation and response to stimuli.

221. (A) Topo I relieves supercoiling without ATP; Topo II needs it
Topoisomerases manage DNA topology through distinct mechanisms. Type I topoisomerases create a single-strand nick and allow the DNA to rotate or pass through the break to relieve supercoiling, a process that does not require ATP hydrolysis. Type II topoisomerases create a double-strand break and pass another segment of the helix through it, which is an energy-intensive process requiring ATP. This energy is used to drive the conformational changes of the enzyme during the reaction.

222. (B) DnaC
During the assembly of the E. coli replisome at the origin of replication, the DnaB helicase must be specifically loaded onto the DNA strands. This role is performed by the DnaC protein, which acts as a helicase loader. DnaC binds to DnaB and facilitates its recruitment to the open complex created by DnaA. Once the helicase is correctly positioned, DnaC dissociates, allowing DnaB to begin unwinding the double helix and initiating the replication process.

223. (A) Template for synthesis of repetitive telomeric sequences
Telomerase is a unique enzyme that combines both protein and RNA components to maintain the ends of linear chromosomes. The RNA part of the enzyme is essential because it contains a sequence that is complementary to the telomeric repeats. Telomerase uses this internal RNA as a template to synthesize new DNA repeats at the 3-prime end of the chromosome. This template-directed synthesis allows the enzyme to compensate for the DNA lost during each round of replication.

224. (A) Alpha subunit
The prokaryotic RNA polymerase is a multi-subunit enzyme. The two alpha subunits play several critical roles beyond just structural assembly. They act as a scaffold for the larger beta and beta-prime subunits and are responsible for interacting with upstream promoter elements. Additionally, the alpha subunits serve as the primary point of contact for various regulatory proteins, allowing the cell to modulate the rate of transcription in response to environmental and metabolic signals.

225. (A) Resides internally, downstream of transcription start
RNA Polymerase III is responsible for transcribing small structural RNAs, such as tRNAs and the 5S rRNA. A unique feature of many genes transcribed by RNA Polymerase III is that their promoter elements are located within the coding region itself, downstream of the transcription start site. These internal promoters are recognized by specific transcription factors that then recruit the polymerase to the correct upstream start site, a configuration distinct from most other genes.

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226. (A) Two successive nucleophilic transesterification reactions
The removal of introns from pre-mRNA is a precise biochemical process carried out by the spliceosome. The mechanism involves two successive transesterification reactions. In the first step, the 2-prime hydroxyl of a conserved adenosine at the branch point attacks the 5-prime splice site. In the second step, the 3-prime hydroxyl of the newly freed upstream exon attacks the 3-prime splice site. This results in the ligation of the two exons and the release of the intron.

227. (A) Degeneracy
The wobble hypothesis explains the flexibility in base pairing at the third position of the codon. Because the third base of the codon and the first base of the anticodon are less spatially constrained, one tRNA can recognize multiple codons. This molecular flexibility directly provides the basis for the degeneracy of the genetic code, where multiple codons often encode the same amino acid. This mechanism makes the translation process more robust and efficient.

228. (C) Non-conservative missense mutation (Asp to Val)
Mutations can have varying effects on protein structure and function. Silent and synonymous mutations do not change the amino acid sequence, while conservative missense mutations replace an amino acid with a chemically similar one. However, a non-conservative missense mutation replaces an amino acid with one that has very

197. (D) Pol gamma : Primary nuclear DNA repair
Eukaryotic cells possess multiple specialized DNA polymerases. Polymerase alpha is associated with primase, while polymerases delta and epsilon are responsible for lagging and leading strand synthesis, respectively. Polymerase gamma is unique because it is the primary enzyme responsible for the replication and repair of mitochondrial DNA. It is not involved in nuclear DNA repair; that role is filled by several other specialized enzymes, including polymerases beta, delta, and epsilon.

198. (A) TATA-binding protein (TBP)
Bacterial promoters are defined by specific conserved DNA sequences that are recognized by the RNA polymerase holoenzyme. These include the -10 and -35 consensus sequences and, in some cases, an upstream UP element. The TATA-binding protein, however, is a critical general transcription factor used in eukaryotes and archaea for the initiation of transcription. TBP is not a component of the standard bacterial transcription machinery, which instead utilizes various sigma factors for promoter recognition.

199. (B) Binds minor groove, bending DNA for PIC assembly
The TATA-binding protein is a universal transcription factor in eukaryotes. When TBP binds to the TATA box sequence in the promoter, it interacts specifically with the minor groove of the DNA. This binding induces a dramatic bend in the DNA double helix. This structural change is crucial because it facilitates the subsequent recruitment and organized assembly of other general transcription factors and RNA polymerase into the pre-initiation complex.

200. (A) P-4, Q-1, R-3, S-2
Post-transcriptional processing in eukaryotes involves several coordinated molecular events to mature pre-mRNA. Capping requires guanylyltransferase to add a modified guanosine to the 5-prime end. Polyadenylation is performed by poly-A polymerase at the 3-prime end. Splicing initiates when the 2-prime hydroxyl group of an internal adenosine attacks the splice site, forming a branch point. Finally, specific small nuclear ribonucleoproteins catalyze the ligation of exons.

201. (A) Degenerate code grouping similar amino acids/codons
The degeneracy of the genetic code is a critical evolutionary feature that minimizes the harmful effects of mutations. Because multiple codons often specify the same amino acid, many single-nucleotide substitutions are silent. Furthermore, codons for chemically similar amino acids are often grouped together. This ensures that even if a mutation changes the amino acid, the resulting protein often retains its functional properties, thereby significantly reducing the overall risk of mutational lethality.

202. (B) Inosine
The structural basis for the wobble hypothesis involves the use of modified nucleotides in the first position of the tRNA anticodon. Inosine is a common modification that can form hydrogen bonds with adenosine, cytidine, and uridine in the third position of the mRNA codon. This versatility allows a single tRNA molecule to recognize multiple different codons, providing the molecular mechanism for the degeneracy observed in the genetic code and increasing translational efficiency.

203. (B) Transesterification catalyzed by 23S/28S rRNA ribozyme
The peptidyl transferase reaction is the fundamental chemical step in protein synthesis, where the growing polypeptide chain is transferred from the tRNA in the P site to the amino acid on the tRNA in the A site. This reaction is a transesterification that is catalyzed by the ribosomal RNA of the large subunit, specifically the 23S rRNA in prokaryotes and the 28S rRNA in eukaryotes, identifying the ribosome as a ribozyme.

204. (B) 16S rRNA binding complementarily to Shine-Dalgarno
In prokaryotes, the correct initiation of translation requires the precise alignment of the 30S ribosomal subunit with the start codon on the mRNA. This alignment is achieved through base pairing between the purine-rich Shine-Dalgarno sequence in the mRNA and a complementary pyrimidine-rich sequence at the 3-prime end of the 16S rRNA. This interaction ensures that the AUG start codon is correctly positioned within the P site of the ribosome for synthesis.

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GATC overhang. This property is extremely useful in recombinant DNA technology, as it allows DNA fragments generated by different enzymes to be ligated together, provided their cohesive ends are complementary.

237. (A) Lambda cos sites enabling in vitro packaging in heads
Cosmids are hybrid vectors that combine the replication properties of plasmids with the packaging system of bacteriophage lambda. Their defining feature is the presence of lambda cos sites. These sequences allow the large recombinant DNA molecule to be packaged in vitro into empty bacteriophage lambda heads. This packaging mechanism is highly efficient and specifically selects for DNA molecules of a certain size, enabling cosmids to accommodate inserts significantly larger than standard plasmids.

238. (A) The T-DNA (Transferred DNA) region of the Ti plasmid
Agrobacterium tumefaciens is a natural genetic engineer used to create transgenic plants. The bacterium contains a large Ti plasmid that carries a specific segment known as the T-DNA. During the infection process, the T-DNA is excised from the plasmid and actively transported into the plant cell. The T-DNA then integrates into the host plant's genomic DNA. Researchers utilize this natural mechanism by replacing the T-DNA genes with foreign genes of interest.

239. (A) The DNA sequence flanking the target region
The success of a Polymerase Chain Reaction depends on the design of specific primers that target a particular DNA sequence. To design these primers, a researcher must know the DNA sequence of the regions flanking the target locus. One primer must be complementary to the 3-prime end of one strand, and the other primer must be complementary to the 3-prime end of the opposite strand. This knowledge ensures that the primers correctly anneal and guide synthesis.

240. (A) Clarification → Primary capture → Polishing → Final formulation
Downstream processing for a secreted recombinant protein involves a series of logical steps to isolate and purify the product from the culture medium. First, clarification removes host cells and debris. Next, primary capture uses affinity or ion-exchange chromatography to isolate the target protein. This is followed by intermediate purification and polishing steps to remove any remaining impurities or aggregated proteins. Finally, the purified protein is prepared in its final formulation for storage or use.

241. (A) Strong, constitutive transcription in mammalian host cells
Recombinant DNA vaccines often utilize the promoter from the human cytomegalovirus to drive the expression of the target antigen. The CMV promoter is one of the strongest known promoters in mammalian cells and provides high levels of constitutive transcription. This ensures that once the plasmid DNA is taken up by the host cell, a large amount of the antigen protein will be produced, which is essential for eliciting a robust and protective immune response.

242. (B) BSL-2
Biosafety levels are assigned based on the potential risk posed by the biological agents being handled. A laboratory that works with indigenous, moderate-risk pathogens that cause common human or animal diseases, such as mild strains of Salmonella, is typically classified as Biosafety Level 2. These facilities require specific training, limited access, and the use of biological safety cabinets for procedures that may generate aerosols, ensuring the safety of the laboratory personnel and environment.

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243. (C) Knowledge was publicly accessible before application date
In intellectual property law, the concept of prior art is a critical barrier to obtaining a patent. Prior art includes any information, such as research papers, public presentations, or existing products, that was publicly accessible anywhere in the world before the filing date of the patent application. If an invention is already known or can be readily derived from prior art, it fails the requirement for novelty and non-obviousness, and therefore cannot be patented.

244. (B) Absorbance at 260 nm due to base unstacking
The hyperchromic shift is a fundamental phenomenon in DNA chemistry observed during the denaturation of the double helix. As the temperature increases and the hydrogen bonds between strands break, the stacked nitrogenous bases become exposed and unstacked. This structural change results in a significant increase in the DNA's absorbance of ultraviolet light at 260 nanometers. This property is used in the

microinjection can transform thousands of cells simultaneously is incorrect.

213. (B) qPCR : Quantification of amplicons in real-time
Polymerase Chain Reaction technology has evolved into several specialized variants. Real-time quantitative PCR is a widely used method that allows for the precise measurement of target DNA concentrations by monitoring the accumulation of amplicons during each cycle using fluorescent signals. Multiplex PCR involves the use of multiple primer pairs to amplify several different loci in a single reaction. RT-PCR is used specifically to amplify sequences from an initial RNA template.

214. (C) Primer length : Optimal between 5 to 8 nucleotides
The specificity of a PCR assay depends on several factors, including temperature and chemical composition. Magnesium is a required cofactor, and the annealing temperature must be carefully optimized. Primer length is also crucial; primers are typically designed to be between 18 and 25 nucleotides long. Primers that are only 5 to 8 nucleotides long would be highly non-specific and would bind to too many random sites in the genome, leading to unsuccessful amplification.

215. (C) It completely lacks any capability for protein glycosylation.
Pichia pastoris is a favored host for recombinant protein expression because it combines the ease of yeast culture with the ability to perform eukaryotic post-translational modifications. It can achieve very high cell densities and utilizes a strong, inducible AOX1 promoter. Unlike Saccharomyces cerevisiae, Pichia does not hyper-glycosylate proteins, making the resulting products more similar to human proteins. Identifying it as completely lacking glycosylation is incorrect, as it is precisely this capability that makes it useful.

216. (A) Formulating plasmid with liposomes or nanoparticles
To ensure the successful administration and efficacy of a DNA vaccine, the plasmid must be protected from degradation and efficiently delivered into host cells. Formulating the DNA with liposomes or synthetic nanoparticles is a key strategy for enhancing its stability in the biological environment. These delivery vehicles shield the negatively charged DNA and facilitate its transport across the cell membrane, thereby improving the overall level of antigen expression and the subsequent immune response.

217. (D) BSL-4
Biosafety Level 4 represents the highest level of biological containment used for working with extremely dangerous and exotic agents. These pathogens pose a high risk of life-threatening disease and are typically transmitted via aerosols. Facilities at this level mandate specialized engineering controls, including dedicated air supplies and positive pressure suits, to ensure the absolute protection of laboratory personnel and the surrounding environment from catastrophic release.

218. (B) Lack of Industrial Applicability/Utility
Intellectual property law requires that an invention must have industrial applicability or utility to be eligible for a patent. A purely abstract mathematical model of DNA folding, while intellectually significant, does not inherently possess a specific, practical, or industrial application on its own. Unless the model is part of a larger, functional process or used to create a tangible product with a defined utility, it would generally fail this fundamental criterion for patentability.

219. (A) A shift from a right-handed to a left-handed helix
The transition from the standard B-DNA to the Z-DNA conformation is a significant structural change. B-DNA is a right-handed helix, while Z-DNA is a left-handed helix. This conversion requires a rotation of the base pairs and a reorganization of the sugar-phosphate backbone into a zigzag pattern. Because these changes involve moving from a lower-energy state to a higher-energy state, the transition requires an energy input and is typically stabilized by specific sequences or torsional strain.

220. (A) A Chromatin Remodeling Complex (e.g., SWI/SNF)
Chromatin remodeling complexes are essential for regulating the accessibility of genomic DNA. These large, multi-subunit assemblies utilize the energy derived from ATP hydrolysis to physically move, evict, or restructure nucleosomes along the DNA. By repositioning the nucleosomes, these complexes can expose promoter sequences and

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205. (A) Scaffold protein linking 5' cap complex to poly(A)
Eukaryotic translation initiation factor eIF_4G plays a vital structural role in the assembly of the translation machinery. It acts as a large scaffold protein that brings together different components of the initiation complex. eIF_4G binds to eIF_4E at the 5-prime cap and to the poly(A) binding protein at the 3-prime end of the mRNA. This interaction circularizes the mRNA, which enhances translational efficiency and promotes the recycling of ribosomal subunits.

206. (C) Destruction by the 26S proteasome
Ubiquitination is a critical post-translational modification that regulates protein levels within the cell. The covalent attachment of a chain of four or more ubiquitin molecules to a target protein serves as a highly specific signal for degradation. This poly-ubiquitin tag is recognized by the 26S proteasome, which subsequently captures, unfolds, and breaks down the tagged protein into short peptides. This system is essential for maintaining cellular protein quality and turnover.

207. (B) Abundant glucose and abundant lactose
The lac operon is only highly expressed when glucose is absent and lactose is present. In the presence of abundant glucose, the cell maintains low levels of cyclic AMP, which prevents the Catabolite Activator Protein from binding to the promoter. Without CAP, RNA polymerase cannot efficiently initiate transcription. Therefore, even if lactose is abundant and the repressor is removed, the overall level of transcription remains very low due to catabolite repression.

208. (A) Recruitment of MBD proteins and chromatin silencing
DNA methylation is a key epigenetic mechanism for gene silencing in mammalian cells. When CpG islands in the promoter of a gene, such as a tumor suppressor, become heavily methylated, they recruit methyl-CpG-binding domain proteins. These MBD proteins then attract additional factors, including histone deacetylases and chromatin remodeling complexes. This results in the formation of a highly condensed, repressive chromatin structure that permanently prevents transcription, potentially contributing to the development of cancer.

209. (A) Perfect or near-perfect Watson-Crick base pairing
In the RNA interference pathway, the specificity of gene silencing is determined by the mature siRNA guide strand. Once incorporated into the RNA-induced silencing complex, the guide strand uses Watson-Crick base pairing to search for complementary sequences in cellular messenger RNAs. For siRNAs, a perfect or near-perfect match with the target mRNA is generally required. This precise interaction triggers the endonucleolytic cleavage of the mRNA by the Argonaute protein within the RISC.

210. (B) BamHI (generates a 5' overhang)
Cohesive or "sticky" ends are highly advantageous for molecular cloning because they facilitate the efficient and directional joining of DNA fragments. Enzymes like BamHI create these ends by making staggered cuts in the palindromic recognition sequence, resulting in 5-prime single-stranded overhangs. These overhangs can easily base-pair with complementary ends on another fragment. In contrast, blunt-end cutters like SmaI and EcoRV generate fragments that are much more difficult to ligate with high efficiency.

211. (A) Cluster of unique sites located within lacZ' marker
A Multiple Cloning Site is an essential feature of modern plasmid vectors. It consists of a dense cluster of unique recognition sites for various restriction endonucleases. The MCS is typically located within the lacZ-prime gene, allowing for blue-white screening. This arrangement provides researchers with great flexibility, as they can choose from several different enzymes to insert their foreign DNA without disrupting the essential regulatory or replication elements of the plasmid.

212. (C) Microinjection transforms thousands of cells simultaneously
Various techniques are used for targeted gene delivery, each with its own advantages and limitations. Electroporation and lipofection are efficient methods for transforming large populations of cells in suspension or culture. Agrobacterium-mediated transfer is the standard for stable plant transformation. However, microinjection is a highly labor-intensive process where DNA is physically injected into a single cell at a time. Therefore, the statement that

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different properties, such as changing a charged aspartate to a hydrophobic valine. If this occurs in a critical active site, it will almost certainly disrupt the enzyme's function.

229. (A) Codon recognition on the mRNA template
During translation, the fidelity of protein synthesis depends on the accurate matching of amino acids with the codons on the mRNA. This is achieved by the tRNA molecule, which acts as an adapter. The anticodon loop of the tRNA contains a specific three-nucleotide sequence that base-pairs with a complementary codon on the mRNA. This codon-anticodon interaction ensures that the amino acid carried by the tRNA is correctly incorporated according to the genetic instructions.

230. (A) Base pair with Shine-Dalgarno to position start codon
The 16S rRNA is a fundamental component of the small ribosomal subunit in prokaryotes. Beyond its structural role, it performs a critical function during the initiation of translation. The 3-prime end of the 16S rRNA contains a sequence that is complementary to the Shine-Dalgarno sequence in the mRNA. By base-pairing with this sequence, the 16S rRNA ensures that the AUG start codon is accurately positioned in the P site of the ribosome for synthesis.

231. (A) Factor binding followed by 50S subunit association
Translation initiation in prokaryotes is a multi-step process involving the assembly of the 30S subunit, mRNA, and the initiator tRNA. This assembly is coordinated by initiation factors IF-1, IF-2, and IF-3. The transition to the elongation phase is specifically marked by the release of these factors and the subsequent binding of the 50S large ribosomal subunit. This results in a functional 70S ribosome with the initiator tRNA correctly positioned in the P site.

232. (D) Binding hydrophobic patches to prevent aggregation
Molecular chaperones, such as the Hsp70 family, are essential for maintaining protein homeostasis within the cell. These proteins bind to exposed hydrophobic patches on newly synthesized or partially unfolded polypeptides. By shielding these hydrophobic regions, chaperones prevent the proteins from forming inappropriate interactions that could lead to aggregation. This stabilization provides the nascent protein with the time and environment necessary to fold into its correct, functional three-dimensional conformation.

233. (A) Binding and progression of RNA polymerase from promoter
In the lac operon, the lac repressor protein regulates gene expression through negative control. The repressor binds specifically to the operator DNA sequence, which is located downstream of and partially overlapping with the promoter. When the repressor is bound, it creates a physical barrier that prevents RNA polymerase from binding to the promoter or progressing along the DNA. This effectively blocks the transcription of the structural genes until an inducer molecule is present.

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234. (A) Maintain structural fold for sequence-specific binding
Many eukaryotic transcription factors utilize a zinc finger motif to interact with DNA. In this structure, one or more zinc ions are coordinated by specific cysteine and histidine residues. The primary function of the zinc ion is to stabilize the small, independent protein domain, allowing it to maintain its correct three-dimensional fold. This specific structural configuration enables the protein to insert an alpha-helix into the major groove of the DNA for sequence-specific recognition.

235. (A) Drosha-DGCR8 (Microprocessor complex)
MicroRNAs are synthesized through a multi-step processing pathway. The initial primary transcripts, or pri-miRNAs, are often several hundred nucleotides long. In the nucleus, these transcripts are recognized and cleaved by the Microprocessor complex, which consists of the RNase III enzyme Drosha and the RNA-binding protein DGCR8. This cleavage produces smaller, hairpin-shaped precursors known as pre-miRNAs, which are then exported to the cytoplasm for further processing by the Dicer enzyme.

236. (B) Distinct sequences but generate identical cohesive ends
Isocaudomers are a group of restriction endonucleases that recognize different DNA sequences but produce identical single-stranded cohesive ends after cleavage. For example, the enzymes BamHI and Sau3AI recognize different sequences but both generate the same 5-prime

by adding imidazole, which competes for the metal binding sites.

174. (D) Completely incapable of post-translational modifications
The Baculovirus expression vector system utilizes insect cell cultures to produce high yields of recombinant proteins. This eukaryotic system is capable of performing a wide range of complex post-translational modifications, including glycosylation, phosphorylation, and proper signal peptide cleavage. Identifying it as completely incapable of these modifications is incorrect. BEVS is particularly valued for expressing large, multi-subunit protein complexes that require a eukaryotic environment for correct folding and biological activity.

175. (A) Affinity chromatography : Specific non-covalent interactions
Protein purification methodologies exploit different physical and chemical properties. Gel filtration separates proteins by size, while ion-exchange chromatography separates them based on net surface charge. Affinity chromatography is unique because it utilizes highly specific, non-covalent biological interactions, such as those between an enzyme and its substrate or an antibody and its antigen. This specificity often allows for the purification of a target protein to near homogeneity in a single step.

176. (C) Ampicillin : Inducer of the T7 promoter
Expression systems utilize specific molecules to control the production of recombinant proteins. IPTG is used to induce promoters derived from the lac operon, while methanol is used for the AOX1 promoter in Pichia pastoris. Ampicillin, however, is an antibiotic used as a selectable marker to ensure only cells carrying the plasmid survive; it does not function as an inducer for the T7 promoter or any other standard expression system.

177. (D) Increasing IPTG concentration to maximize induction rate
Improving the solubility of recombinant proteins in E. coli is a common challenge in biotechnology. Effective strategies include lowering the growth temperature to slow down protein synthesis, co-expressing chaperones to aid folding, and using soluble fusion tags like GST. In contrast, increasing the IPTG concentration to maximize the induction rate often exacerbates the problem by overwhelming the cell's folding machinery, leading to the rapid formation of insoluble inclusion bodies.

178. (A) Presents purified immunogenic fragment to elicit response
Recombinant subunit vaccines represent a modern and safe approach to immunization. Instead of using whole pathogens, these vaccines consist of specific, purified immunogenic fragments of the pathogen, such as surface proteins, which are produced using recombinant DNA technology. By presenting only the essential parts of the organism needed to trigger an immune response, these vaccines eliminate the risk of causing the disease while still providing effective protection against future infections.

179. (A) Delivers plasmid encoding antigen for host expression
DNA vaccines represent a novel immunization strategy where the genetic material for an antigen is delivered directly into the host's cells. A plasmid vector encoding the target protein is taken up by the host's cells, which then use their own machinery to transcribe and translate the antigen. This intracellular production of the antigen can effectively stimulate both humoral and cell-mediated immune responses, providing a broader range of protection than traditional protein-based vaccines.

180. (A) Vector enters → Genome expressed → Antigen presented
Viral vector vaccines utilize a harmless virus to deliver the genetic information for a pathogen's antigen into host cells. Following administration, the viral vector enters the host cells and releases its genome. The host cell's machinery then expresses the target antigen. The synthesized antigen is subsequently presented on the surface of the cell, where it is recognized by the immune system, triggering the production of antibodies and the activation of T-cells.

181. (C) Attenuated Adenovirus or Poxvirus for antigen delivery
In the development of recombinant viral vector vaccines for animals, researchers often choose viruses that are well-characterized and safe. Attenuated adenoviruses or poxviruses, such as the canarypox virus, are commonly used as delivery vehicles. These viruses are engineered to carry the gene for a protective antigen from

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laboratory to determine the melting temperature and stability of various DNA molecules.

245. (D) Nucleosome core consists of two copies of each core histone
The nucleosome core particle is the basic structural unit of eukaryotic chromatin. It is composed of a protein octamer and approximately 147 base pairs of DNA. The octamer consists of two copies each of the core histones H2A, H2B, H3, and H4. The DNA is wrapped around this octamer in a left-handed superhelix. Histone H1 is not part of the core octamer; instead, it binds to the linker DNA to stabilize the higher-order chromatin structure.

246. (D) Solely responsible for preventing separated strands reannealing
DNA helicases are essential enzymes that use ATP hydrolysis to separate the two strands of the DNA double helix during replication and transcription. While they are responsible for the initial unwinding and move unidirectionally along a strand, they are not solely responsible for preventing the strands from reannealing. That role is primarily performed by single-stranded binding proteins, which bind to and stabilize the exposed single strands, keeping them accessible for the DNA polymerase machinery.

247. (C) Prokaryotic fragment size : 1000-2000 nucleotides
During the discontinuous synthesis of the lagging strand, DNA is produced in short segments known as Okazaki fragments. The size of these fragments differs significantly between organisms. In prokaryotes, such as E. coli, Okazaki fragments are relatively large, typically ranging from 1000 to 2000 nucleotides in length. In eukaryotes, the fragments are much shorter, generally only 100 to 200 nucleotides long, reflecting the slower replication speed and more complex chromatin organization.

248. (D) Telomere sequence : Highly variable, non-repeating codes
Telomeres are specialized structures at the ends of linear chromosomes that protect them from degradation and fusion. They consist of highly repetitive, conserved DNA sequences, such as TTAGGG in humans, rather than variable codes. Telomerase maintains these ends using its reverse transcriptase activity. The formation of structures like the T-loop provides further protection. The progressive loss of these telomeric repeats eventually leads to the Hayflick limit, where cells undergo replicative senescence.

249. (A) Rho factor
The initiation phase of prokaryotic transcription involves several key components, including the RNA polymerase core enzyme, the sigma factor, and specific promoter sequences at the -10 and -35 regions. The sigma factor is essential for recognizing the promoter and initiating synthesis. In contrast, the Rho factor is a specialized protein involved exclusively in the termination phase of transcription. Rho acts as an ATP-dependent helicase that helps release the newly synthesized RNA from the DNA template.

250. (A) Both A and R are true and R is the correct explanation of A.
Transcription initiation in eukaryotes is significantly more complex than in prokaryotes. While the bacterial RNA polymerase core enzyme can initiate synthesis with a sigma factor, eukaryotic RNA Polymerase II cannot recognize promoter sequences independently. It requires the sequential assembly of several general transcription factors to form a pre-initiation complex. This assembly is mandatory for the polymerase to bind correctly and begin RNA synthesis at the basal level, ensuring precise regulation of gene expression.

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251. (C) Nucleus, co-transcriptionally or immediately post-transcription
In eukaryotic cells, the process of RNA splicing is tightly regulated both spatially and temporally. Splicing occurs exclusively within the nucleus. For most genes, splicing begins co-transcriptionally, meaning the spliceosome starts removing introns while the RNA polymerase is still synthesizing the remainder of the transcript. This nuclear compartmentalization ensures that only fully processed, mature messenger RNAs are exported to the cytoplasm for translation by the ribosomes, preventing the synthesis of defective proteins.

252. (B) Converts standard amino acid codon into termination codon
Point mutations in the coding region of a gene can have different effects on the resulting protein. A missense mutation changes one amino acid to another, which may or may not affect protein function. In contrast, a nonsense mutation is a

297. (A) Western Blotting
Western blotting is a powerful analytical technique used to detect specific proteins within a complex mixture. The process involves separating proteins by size using gel electrophoresis and kemudian transferring them to a membrane. The membrane is kemudian incubated with a specific antibody that binds only to the target protein. By using a labeled secondary antibody, researchers can visually confirm the presence of the protein and estimate its molecular weight, providing definitive proof of successful recombinant expression.

298. (A) Host's immune system neutralizes delivery vector before infection
Pre-existing immunity is a significant challenge for the efficacy of viral vector vaccines. This occurs when the human or animal host has been previously exposed to the virus used as the delivery vector, or a closely related strain. Upon administration of the vaccine, the host's immune system recognizes the viral vector and produces antibodies that neutralize it before it can enter the cells and deliver the target antigen. This prevents the synthesis of the antigen and significantly reduces the overall immune response.

299. (A) Agents cause lethal disease through respiratory transmission
Biosafety Level 3 laboratories are specialized containment facilities designed for working with dangerous biological agents that pose a high risk to personnel and the environment. These pathogens, such as the bacteria that cause tuberculosis, are typically characterized by their ability to cause serious or potentially lethal disease specifically through respiratory or aerosol transmission. BSL-3 facilities require advanced engineering controls, including directional airflow and HEPA filtration of exhaust air, to prevent the escape of infectious particles.

300. (C) Specific engineered genetic sequence and novel creation method
Intellectual property rights in biotechnology provide legal protection for novel and useful inventions rather than naturally occurring biological entities. For a transgenic plant, a patent specifically covers the unique, engineered genetic sequence that provides a new trait and the specific technical process used to create the organism. This legal framework incentivizes innovation by granting developers exclusive rights to commercially exploit their technical advancements for a limited period, while requiring them to disclose their findings to the public.

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260. (A) P-1, Q-2, R-3, S-4
Cloning vectors differ in their ability to accommodate foreign DNA inserts. Standard plasmids generally handle small fragments up to 10 kilobases. Bacteriophage lambda vectors can carry slightly larger inserts, typically between 10 and 20 kilobases. Cosmids, which utilize phage packaging, have a capacity of 35 to 45 kilobases. For exceptionally large genomic fragments exceeding 300 kilobases, Yeast Artificial Chromosomes are used, as they are designed to replicate like actual yeast chromosomes.

261. (B) Two sequence-specific primers flanking target in opposite orientations
The exponential amplification of DNA in a PCR reaction is achieved through the use of two sequence-specific primers. These primers must be designed to flank the target locus on opposite strands of the DNA. During each cycle, one primer guides the synthesis of a new strand in one direction, while the second primer guides synthesis in the opposite direction. This arrangement ensures that the region between the two primers is specifically and repeatedly duplicated in every cycle.

262. (B) Physical binding of 30S ribosomal subunit for initiation
When expressing recombinant proteins in bacterial systems, the messenger RNA must be correctly recognized by the host's translation machinery. The inclusion of a Shine-Dalgarno sequence upstream of the start codon is essential for this process. The Shine-Dalgarno sequence base-pairs with the 16S rRNA of the host's 30S ribosomal subunit. This interaction ensures that the ribosome is accurately positioned on the mRNA, allowing for the efficient initiation of translation and the production of the recombinant protein.

263. (A) Enhance immunogenicity and stimulate innate immune response
Recombinant subunit vaccines often consist of purified proteins that may not be strongly recognized by the immune system on their own. To improve their effectiveness, these vaccines are frequently formulated with an adjuvant. Adjuvants are substances that enhance the immunogenicity of the antigen by stimulating the innate immune response and providing a "danger signal" to the body. This leads to a more robust and long-lasting adaptive immune response, ensuring that the vaccine provides effective protection.

264. (A) Disease severity, route of transmission, and treatments
Biosafety risk assessments are a systematic way to categorize biological pathogens and determine the appropriate level of containment for research. The primary factors considered in this assessment are the severity of the disease caused by the pathogen, the ease and route of its transmission, and the availability of effective vaccines or therapeutic treatments. This classification ensures that dangerous agents are handled in facilities with the necessary physical barriers and safety protocols to protect laboratory workers.

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265. (A) Not readily deducible by a person with ordinary skill
Under international intellectual property standards, the criterion of "non-obviousness" or "inventive step" is essential for obtaining a patent. This means that a biotechnological process or invention must represent a significant technical advancement that was not readily deducible by someone with ordinary skill and knowledge in that specific field at the time the application was filed. This requirement ensures that patents are only granted for truly innovative developments rather than for routine or trivial scientific improvements.

266. (C) Base stacking interactions involve non-covalent van der Waals forces and dipole-dipole interactions.
The structural stability of the DNA double helix is maintained by a combination of forces. While hydrogen bonding provides specificity, base stacking interactions provide significant thermodynamic stability. These interactions occur between the planar surfaces of adjacent base pairs and involve non-covalent van der Waals forces and dipole-dipole interactions. GC-rich regions have higher melting temperatures than AT-rich regions because they have three hydrogen bonds per pair, and high salt concentrations actually stabilize DNA by neutralizing phosphate repulsion.

267. (C) It always results in the permanent eviction of the histone octamer.
Chromatin remodeling is a dynamic and ATP-dependent process that regulates DNA accessibility in eukaryotes. These complexes

the background. By comparing the Ct values of unknown samples against a standard curve generated from known concentrations of the target DNA, researchers can precisely calculate the initial number of copies present.

283. (A) Precise replication of human-like N-glycosylation patterns
Mammalian cell expression systems, such as Chinese Hamster Cho cells, are often preferred over yeast or bacteria for producing human therapeutic proteins. The primary reason is that mammalian cells possess the complex enzymatic machinery required to perform precise and human-like post-translational modifications, particularly N-linked glycosylation. These specific carbohydrate patterns are often essential for the proper folding, biological activity, and stability of the protein, as well as for avoiding adverse immune responses when administered to patients.

284. (A) Antigen synthesized intracellularly and presented on MHC I
Recombinant DNA vaccines are particularly effective at inducing a potent cellular immune response, including the activation of cytotoxic T-lymphocytes. This occurs because the vaccine delivers a plasmid that is taken up by the host cells, which then synthesize the antigen protein themselves. Because the antigen is produced intracellularly, it is naturally processed and presented on the cell surface via MHC Class I molecules. This presentation is the specific signal required to activate CTLs to recognize and destroy infected cells.

285. (C) Open-bench manipulation of lethal aerosol-transmitted agents
Biosafety Level 2 laboratories are designed for working with moderate-risk agents that cause human disease. Standard procedures include restricted access, routine decontamination, and the use of biological safety cabinets for any work that might create aerosols. However, the open-bench manipulation of dangerous agents that are known to be transmitted via aerosols is fundamentally incompatible with BSL-2. Such high-risk procedures must be conducted in higher containment facilities, such as BSL-3 or BSL-4, with additional specialized safety equipment.

286. (A) Exclusive rights to exploit invention for a limited period
The fundamental legal purpose of obtaining a patent for a biotechnological invention is to grant the inventor exclusive commercial rights for a specified period, typically twenty years. In exchange for publicly disclosing the details of the invention, the patent holder has the right to prevent others from making, using, or selling the patented technology without permission. This system provides a powerful economic incentive for companies and researchers to invest in the costly development of new biotechnological products and processes.

287. (A) Restriction digestion → Ligation → Transformation → Screening
The creation of a recombinant plasmid follows a logical, step-by-step experimental procedure. First, both the vector and the foreign DNA are cut with specific restriction enzymes. Next, the resulting fragments are joined together using DNA ligase to form the recombinant plasmid. This DNA is then introduced into competent bacterial cells through transformation. Finally, the transformed cells are grown on selective media and screened, often using methods like blue-white screening, to identify those that successfully took up the recombinant plasmid.

288. (A) Heterochromatin
Eukaryotic chromatin exists in two primary functional states. Euchromatin is less condensed and contains most of the actively transcribed genes. In contrast, heterochromatin is characterized by a highly condensed structure, a low density of genes, and high levels of DNA methylation and repressive histone modifications. Heterochromatin is generally transcriptionally inactive and plays a key role in maintaining genome stability and regulating gene silencing across large regions of the chromosome, such as centromeres and telomeres.

289. (A) DnaG (Primase)
DNA polymerases cannot initiate the synthesis of a new DNA strand from scratch; they require a 3-prime hydroxyl group to add nucleotides. Therefore, all DNA replication begins with the synthesis of a short RNA primer. In prokaryotes, the enzyme responsible for this task is DnaG, also known as primase. Primase synthesizes the RNA primers required for both the leading strand and for each individual Okazaki fragment

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275. (A) Recognize codon and trigger polypeptide ester hydrolysis
Translation termination occurs when the ribosome encounters a stop codon. Because there are no tRNAs for these codons, release factors like RF_1 and RF_2 enter the A site instead. These protein factors are designed to recognize the specific stop codon sequences. Once bound, they interact with the peptidyl transferase center of the ribosome, causing it to use a water molecule to hydrolyze the ester bond between the final amino acid and the tRNA, releasing the completed polypeptide.

276. (A) Tryptophan
The tryptophan operon is a repressible system that allows E. coli to control the synthesis of this essential amino acid. The Trp repressor protein is produced in an inactive form, known as an aporepressor. It only becomes functionally active when it binds to tryptophan, which acts as a corepressor. When tryptophan levels are high, the active repressor-tryptophan complex binds to the operator, blocking transcription. When tryptophan is scarce, the repressor remains inactive, allowing the operon to be expressed.

277. (A) Methyl group attachment at C_5 of cytosine in CpG sites
Epigenetic regulation in mammalian genomes is frequently mediated by the methylation of DNA. This process involves the covalent attachment of a methyl group to the C_5 position of the cytosine ring, typically occurring at CpG dinucleotide sites. This modification is carried out by DNA methyltransferase enzymes. Methylation at promoter regions is a stable mark that generally leads to transcriptional silencing, playing a critical role in cellular differentiation, genomic imprinting, and the long-term regulation of gene expression.

278. (A) Multiple mature mRNAs encoding distinct protein isoforms
Alternative splicing is a powerful regulatory mechanism in eukaryotes that increases the functional diversity of the genome. During the processing of a single pre-mRNA molecule, different combinations of exons can be joined together while introns are removed. This process can generate multiple distinct mature messenger RNA transcripts from the same gene. Each of these transcripts can then be translated into a different protein isoform with unique structural or functional properties, allowing for complex regulation of biological processes.

279. (A) Creates phosphodiester bond using ATP or NAD+ energy
DNA ligase is an essential enzyme for both natural DNA replication and recombinant DNA technology. Its primary biochemical function is to catalyze the formation of a covalent phosphodiester bond between the 3-prime hydroxyl group of one DNA strand and the 5-prime phosphate group of another. This reaction requires an external energy source, which is typically ATP in eukaryotes and either ATP or NAD+ in prokaryotes. This enzymatic action is used to permanently join DNA fragments and seal nicks.

280. (A) II only
Cloning vectors are designed with specific insert capacities. Plasmids are generally used for small fragments up to 10 kilobases; however, the statement identifying this as an incorrect range is misleading, as plasmids can sometimes handle slightly larger fragments. Cosmids use phage packaging, BACs are based on the F-plasmid, and YACs require centromeres and telomeres. Therefore, the most accurate evaluation depends on the specific limitations of the question, but plasmids are typically the most limited in capacity.

281. (A) Free of salts to prevent severe electrical arcing in cuvette
To prepare bacterial cells for transformation via electroporation, they must be thoroughly washed and resuspended in a non-conductive buffer, such as chilled sterile water or glycerol. This is critical because the presence of salts in the buffer would make the solution highly conductive. If an electrical pulse were applied to a salt-containing solution, it would cause severe electrical arcing and heat generation in the cuvette, which would kill the cells and prevent successful transformation.

282. (A) Comparing threshold cycle (Ct) against a standard curve
Real-time quantitative PCR is a highly sensitive method for determining the absolute quantity of a specific DNA sequence in a sample. This is achieved by determining the threshold cycle for each sample, which is the cycle number where the fluorescence signal rises significantly above

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can slide nucleosomes along the DNA or alter their spacing to expose specific sequences. While remodeling can occasionally lead to the displacement of histones, it does not always result in the permanent eviction of the histone octamer. Often, the nucleosomes are simply repositioned or their structure is transiently loosened to allow the transcription machinery to bind to the DNA.

268. (A) DNA Ligase : Phosphodiester bond formation between Okazaki fragments
DNA replication involves several enzymes with highly specialized functions. During lagging strand synthesis, the DNA is produced in discontinuous Okazaki fragments. Once the RNA primers are removed and replaced with DNA, the enzyme DNA ligase is responsible for joining the fragments together. It catalyzes the formation of a covalent phosphodiester bond between the 3-prime hydroxyl group and the 5-prime phosphate group of adjacent fragments, ensuring the creation of a continuous and stable DNA strand.

269. (C) E. coli Pol I : Eukaryotic Telomerase equivalent
Replication enzymes in prokaryotes and eukaryotes often perform analogous roles. E. coli DNA polymerase III and eukaryotic polymerases delta/epsilon both provide processive synthesis. E. coli primase and the primase associated with eukaryotic polymerase alpha both initiate strands. The beta-clamp and PCNA both serve as processivity factors. However, E. coli polymerase I is involved in primer removal and DNA repair, which is not functionally equivalent to telomerase, an enzyme specialized for maintaining the ends of linear chromosomes.

270. (A) I and II
Prokaryotic transcription termination occurs through two primary mechanisms. Rho-dependent termination requires the Rho protein, an ATP-dependent helicase that tracks along the RNA and helps release it from the polymerase. Rho-independent, or intrinsic, termination relies on the formation of a GC-rich hairpin followed by a poly-U sequence in the mRNA. Neither mechanism requires the sigma factor; the sigma factor is only involved in the initiation phase of transcription to help recognize the promoter.

271. (C) Export through the nuclear pore complex to the cytoplasm
In eukaryotes, many steps of RNA processing occur co-transcriptionally, meaning they happen while the RNA polymerase is still synthesizing the transcript. These include the addition of the 5-prime cap, the initiation of splicing, and the interaction of processing enzymes with the polymerase's carboxy-terminal domain. In contrast, the export of the major messenger RNA through the nuclear pore complex to the cytoplasm is a separate process that only occurs after these processing steps are completed.

272. (A) Stripped human gene correctly translated by bacterial host
The near-universality of the genetic code is a cornerstone of biotechnology. Because nearly all organisms use the same codons to specify the same amino acids, a gene isolated from one species can be accurately expressed in another. For example, a human gene for a protein like insulin, once stripped of its introns, can be introduced into a bacterial host. The bacterium's machinery will read the human codons and synthesize a protein with the correct human amino acid sequence.

273. (A) U or C
The wobble hypothesis describes the flexible base pairing that can occur at the third position of the codon. According to these rules, the base in the first position of the tRNA anticodon determines its pairing versatility. If a tRNA has a guanine at the 5-prime wobble position of its anticodon, it can form hydrogen bonds with either a uridine or a cytidine at the 3-prime position of the mRNA codon. This flexibility explains why fewer tRNAs are needed.

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274. (D) Recognition of the Shine-Dalgarno sequence
Translation is divided into three distinct phases: initiation, elongation, and termination. The elongation phase involves the repeated cycle of aminoacyl-tRNA binding to the A site, peptide bond formation by the peptidyl transferase center, and the translocation of the ribosome along the mRNA. The recognition of the Shine-Dalgarno sequence, however, is a specific event that occurs only during the initiation phase in prokaryotes, ensuring the correct placement of the 30S ribosomal subunit on the mRNA.

on the lagging strand, providing the necessary starting point for DNA polymerase III.

290. (A) I, II and V
Eukaryotic translation initiation is a complex, energy-dependent process. It begins with the recognition of the 5-prime cap by eIF_4E. The 40S ribosomal subunit then binds and scans the mRNA in a process that requires ATP hydrolysis. The ribosome searches for the start codon, typically within the context of the Kozak sequence. Unlike prokaryotes, the eukaryotic initiator tRNA carries standard methionine, not N-formylmethionine, and the process does not utilize a Shine-Dalgarno sequence for initial ribosomal binding.

291. (A) Exonuclease cleavage that eventually "torpedoes" polymerase
The termination of transcription by eukaryotic RNA Polymerase II is described by the "torpedo" model. After the polymerase transcribes the polyadenylation signal, the RNA is cleaved. A specialized 5-prime to 3-prime exonuclease then binds to the remaining RNA that is still attached to the polymerase. The exonuclease rapidly degrades this RNA, catching up to the moving polymerase. When it reaches the enzyme, it triggers the dissociation of the polymerase from the DNA template, effectively ending transcription.

292. (A) It allows a single tRNA to recognize multiple codons for the same amino acid.
In the prokaryotic genetic code, the "wobble" hypothesis explains how the cell can function with fewer than sixty-one different tRNAs. The pairing at the third position of the codon and the first position of the anticodon is less spatially restricted, allowing for non-standard base pairs. This flexibility enables a single tRNA molecule to recognize and bind to multiple different codons that specify the same amino acid. This mechanism increases the efficiency of translation and provides robustness against certain mutations.

293. (A) Hsp70 : Co-translational folding binding hydrophobic patches
Molecular chaperones utilize different mechanisms to assist in protein folding. The Hsp70 family of chaperones functions primarily by binding to exposed hydrophobic patches on nascent polypeptides as they emerge from the ribosome. This co-translational binding prevents the proteins from misfolding or aggregating prematurely. Other chaperones, like GroEL/ES, provide a protected chamber for folding, while the signal recognition particle (SRP) is involved in targeting proteins to the endoplasmic reticulum rather than refolding aggregated proteins.

294. (D) Attenuation : Pre-transcriptional blockage of RNA polymerase binding
Attenuation is a regulatory mechanism observed in prokaryotic operons like the tryptophan operon that couples transcription and translation. It does not block the initial binding of RNA polymerase to the promoter. Instead, it involves the formation of alternative secondary structures in the nascent messenger RNA that signal the polymerase to terminate transcription prematurely before the structural genes are reached, based on amino acid availability. This occurs after the initiation of transcription.

295. (D) Prokaryotic Shine-Dalgarno sequence upstream of target gene
Generic eukaryotic plasmid vectors are designed with specific elements to ensure robust expression in mammalian cells. These include strong promoters for transcription, polyadenylation signals for mRNA stability, and eukaryotic origins of replication for maintenance. However, the inclusion of a prokaryotic Shine-Dalgarno sequence is not helpful in this context. Eukaryotic ribosomes do not recognize Shine-Dalgarno sequences; instead, they utilize the 5-prime cap and the scanning mechanism to identify the correct start codon for translation.

296. (A) Generates intron-free cDNA from mRNA for prokaryotic use
Reverse transcription is a vital tool in recombinant DNA technology, especially when expressing eukaryotic genes in prokaryotic hosts like E. coli. Because bacteria cannot remove introns from eukaryotic pre-mRNA, researchers use reverse transcriptase to synthesize a complementary DNA strand from a mature, already spliced messenger RNA template. This results in an "intron-free" cDNA that can be directly transcribed and translated by the bacterial host's machinery, allowing for the successful production of eukaryotic proteins.

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single-base change that converts a codon for an amino acid into one of the three stop codons. This results in the premature termination of translation and the production of a truncated, usually non-functional, protein.

253. (B) Terminates with 5'-CCA-3', where the amino acid attaches
Transfer RNA molecules possess a highly conserved structure that is essential for their function as adapters in translation. A universal feature of all mature tRNAs is the presence of a 5-prime CCA 3-prime sequence at their 3-prime terminus. This sequence, known as the acceptor stem, is the site where a specific amino acid is covalently attached by an aminoacyl-tRNA synthetase. This CCA end is required for the tRNA to interact correctly with the ribosome.

254. (D) Ribosomal exoribonucleolytic degradation of nascent peptides
Maintaining high fidelity during translation is essential for life and involves multiple steps. Aminoacyl-tRNA synthetases use proofreading sites to ensure correct tRNA charging. The ribosome monitors the accuracy of codon-anticodon pairing, and EF-Tu provides a kinetic proofreading step using GTP hydrolysis. However, the ribosome does not possess an exoribonucleolytic activity to degrade nascent peptides; such a mechanism would be destructive. Instead, defective proteins are typically targeted for degradation by the ubiquitin-proteasome system after synthesis.

255. (A) Co-translational translocation
In eukaryotic cells, proteins destined for secretion or for various organelles must be directed to the endoplasmic reticulum. This process often occurs via co-translational translocation. As the nascent polypeptide emerges from the ribosome, a signal sequence is recognized by the signal recognition particle. The SRP then halts translation and brings the entire ribosome-nascent chain complex to the ER membrane. Translation then resumes, and the protein is synthesized directly into the lumen of the ER.

256. (A) Related genes transcribed from a promoter to polycistronic mRNA
An operon is a fundamental unit of genetic organization in prokaryotes. It consists of a cluster of functionally related structural genes that are under the control of a single promoter and regulatory elements, such as an operator. When the operon is transcribed, it produces a single, long polycistronic messenger RNA that contains the coding sequences for all the genes in the cluster. This arrangement allows the bacterium to efficiently coordinate the expression of entire metabolic pathways.

257. (A) DNA looping mediated by architectural proteins and Mediator
Enhancers are regulatory elements that can control gene expression from great distances. To interact with the basal transcription machinery at a distant promoter, the intervening DNA must be folded. This interaction is achieved through DNA looping, which is facilitated by various architectural proteins and the large Mediator complex. This physical contact allows transcription factors bound at the enhancer to influence the assembly or activity of the pre-initiation complex, even when the enhancer is located far away.

258. (A) Perfect or near-perfect Watson-Crick base pairing
Small interfering RNAs are highly specific tools for gene silencing in the RNA interference pathway. When an siRNA is incorporated into the RNA-induced silencing complex, it uses its guide strand to find target messenger RNAs. For siRNAs, a perfect or near-perfect Watson-Crick base pairing with the target is generally required. This precise match triggers the Argonaute protein to cleave the mRNA backbone, leading to the rapid and specific destruction of the target transcript.

259. (A) Homodimer cleaving both strands of the DNA symmetrically
Classic Type II restriction endonucleases are typically small, simple enzymes that function as homodimers. These enzymes recognize a specific, usually palindromic, DNA sequence. Each subunit of the dimer catalyzes the cleavage of a phosphodiester bond on one strand of the DNA double helix. Because the enzyme acts symmetrically, it produces clean, predictable fragments with either blunt or cohesive ends. This biochemical simplicity and precision make them invaluable tools for molecular cloning and DNA analysis.

NODIA

CHAPTER 07
Vitamins

2011

1. An essential vitamin is biochemically defined primarily as an organic compound that is:
(A) Synthesized in sufficient quantities by the host organism to sustain metabolism
(B) Required in trace amounts to act specifically as a coenzyme or structural precursor
(C) Utilized primarily as a direct source of metabolic energy during starvation
(D) Incorporated strictly into cellular membranes for structural integrity

2018

2. Which of the following statements correctly identifies a factual distinction between water-soluble and lipid-soluble vitamins?
(A) Lipid-soluble vitamins are excreted rapidly in urine, while water-soluble vitamins are stored in the liver
(B) Water-soluble vitamins require bile salts for intestinal absorption
(C) Water-soluble vitamins are entirely synthesized by animal cells
(D) Lipid-soluble vitamins are generally stored in the body and pose a higher risk of toxicity

2016

3. Identify the INCORRECT pair regarding provitamins and their corresponding active vitamins.
(A) Tryptophan – Vitamin C
(B) Beta-carotene – Vitamin A
(C) Ergosterol – Vitamin D_2
(D) 7-dehydrocholesterol – Vitamin D_3

2024

4. In avian species, which specific precursor is heavily relied upon for the endogenous synthesis of niacin?
(A) Phenylalanine
(B) Tyrosine
(C) Tryptophan
(D) Histidine

2022

5. Based on functional classification, which vitamin is exceptionally classified as a steroid hormone precursor?
(A) Vitamin D
(B) Vitamin C
(C) Vitamin A
(D) Vitamin K

2013

6. A deficiency in which water-soluble vitamin directly impairs the synthesis of Coenzyme A (CoA)?
(A) Riboflavin (Vitamin B_2)
(B) Pyridoxine (Vitamin B_6)
(C) Folic acid (Vitamin B_9)
(D) Pantothenic acid

2016

7. The most relevant primary physiological role of alpha-tocopherol is to:
(A) Regulate calcium transport across the intestinal mucosa
(B) Serve as an intracellular chain-breaking antioxidant
(C) Act as a coenzyme in the carboxylation of glutamic acid
(D) Facilitate the conversion of pyruvate to acetyl-CoA

2019

8. In which classification system are vitamins strictly categorized by their solubility in aqueous versus non-polar solvents?
(A) Functional classification
(B) Biosynthetic classification
(C) Physicochemical classification
(D) Therapeutic classification

2012

9. Both animals and humans require dietary vitamins; however, most mammals do not require dietary Vitamin C. What is the cause of this exception in specific species like guinea pigs and primates?
(A) Overexpression of the L-gulonolactone oxidase enzyme
(B) Enhanced intestinal microbial synthesis of ascorbic acid
(C) Accelerated renal reabsorption of dietary ascorbic acid

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(D) Mutation causing loss of functional L-gulonolactone oxidase

2008

10. Match the following provitamins or compounds in List I with their related vitamin forms in List II:

List I: (Provitamins/Compounds)

P. Beta-carotene
Q. Panthenol
R. 7-Dehydrocholesterol
S. Menadione

List II: (Vitamin Forms)

1. Vitamin K_3
2. Cholecalciferol
3. Retinol
4. Pantothenic acid

(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-4, R-3, S-1

2019

11. Which vitamin acts as a coenzyme for transaminases and decarboxylases in amino acid metabolism?
(A) Thiamine pyrophosphate
(B) Pyridoxal phosphate
(C) Flavin adenine dinucleotide
(D) Nicotinamide adenine dinucleotide

2022

12. Which of the following statements correctly describes the function of biotin (Vitamin B_7)?
(A) It acts primarily as an essential electron carrier in the respiratory chain
(B) It acts as a mobile carrier of CO_2 during enzymatic carboxylation reactions
(C) It provides the structural backbone for the synthesis of coenzyme A
(D) It is an essential component of the visual cycle in the rod cells of the retina

2011

13. The structure of which water-soluble vitamin features a corrin ring containing a central cobalt ion?
(A) Cyanocobalamin
(B) Phylloquinone
(C) Pantothenic acid
(D) Ergocalciferol

2008

14. Which functional moiety of thiamine pyrophosphate (TPP) is responsible for its catalytic activity in the oxidative decarboxylation of alpha-keto acids?
(A) The pyrimidine ring
(B) The methylene bridge
(C) The thiazole ring
(D) The pyrophosphate tail

2019

15. The active coenzyme forms of riboflavin include which of the following?
(A) NAD+ and NADP+
(B) TPP and PLP
(C) THF and DHF
(D) FMN and FAD

NODIA

2011

16. In the structure of Vitamin C, which feature is critical for its reducing properties?
(A) An aromatic benzene ring
(B) A sulfhydryl group
(C) An enediol functional group
(D) A carboxylate side chain

2002

17. The primary biochemical consequence of folate deficiency is the impairment of:
(A) Acyl-group transfer reactions
(B) One-carbon transfer reactions
(C) Oxidative phosphorylation
(D) Glycogenolysis

2016

18. Niacin can be synthesized endogenously from tryptophan. Which vitamin is an essential coenzyme for this specific pathway?
(A) Thiamine
(B) Riboflavin
(C) Cyanocobalamin
(D) Pyridoxine

2006

19. What is the least relevant function of Vitamin C among the following?
(A) Coenzyme for pyruvate dehydrogenase complex
(B) Hydroxylation of proline and lysine in collagen
(C) Reduction of dietary iron to enhance intestinal absorption
(D) Antioxidant scavenging of reactive oxygen species

2011

20. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Pantothenic acid is essential for the oxidation of fatty acids.
Reason (R): Pantothenic acid is an integral structural component of Coenzyme A, which is required for the formation of acyl-CoA.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

2025

21. Which coenzyme is required for the conversion of methylmalonyl-CoA to succinyl-CoA?
(A) 5'-deoxyadenosylcobalamin
(B) 5,6,7,8-tetrahydrofolate
(C) Pyridoxal 5'-phosphate
(D) Biotin-lysine complex

2018

22. Which of the following pairs of B-complex vitamins and their active forms is strictly INCORRECT?
(A) Riboflavin – FAD
(B) Niacin – NADP+
(C) Pyridoxine – Pyridoxamine phosphate
(D) Thiamine – Thiamine monophosphate

2003

23. A characteristic structural feature of folic acid is the presence of:
(A) A pyrimidine ring, a thiazole ring, and pyrophosphate
(B) A pteridine ring, p-aminobenzoic acid, and glutamic acid
(C) An isoalloxazine ring and ribitol
(D) A pyridine ring and a carboxamide group

2015

24. Which form of vitamin B_6 is primarily transported in the systemic circulation?
(A) Pyridoxine hydrochloride
(B) Pyridoxal hydrochloride
(C) Pyridoxal 5'-phosphate
(D) Pyridoxamine phosphate

2018

25. The core structural unit of all lipid-soluble vitamins is ultimately derived from:
(A) Acetyl-CoA via the citric acid cycle
(B) Porphyrin rings
(C) Amino acid precursors
(D) Isoprene units

2003

26. Which transport protein is exclusively responsible for the mobilization of Vitamin A from hepatic stores to peripheral tissues?
(A) Retinol-binding protein (RBP)
(B) Serum albumin proteins
(C) Transthyretin complexes
(D) Chylomicron particles

2006

27. The physiologically active form of Vitamin D_3 (Cholecalciferol) generated after renal hydroxylation is:
(A) 25-hydroxycholecalciferol
(B) 1,25-dihydroxycholecalciferol
(C) 24,25-dihydroxycholecalciferol
(D) Ergocalciferol

2016

28. Which of the following lipid-soluble vitamins directly functions in the gamma-carboxylation of glutamic acid residues in clotting factors?
(A) Vitamin K
(B) Vitamin A
(C) Vitamin D
(D) Vitamin E

2018

29. The absorption of lipid-soluble vitamins in the small intestine is strictly dependent on the presence of:
(A) Bile salts and dietary lipids
(B) Intrinsic factor
(C) High levels of dietary fiber
(D) Ascorbic acid

2008

30. Consider the following statements regarding Vitamin A:
I. Retinal is a component of rhodopsin.
II. Retinoic acid regulates gene expression.
III. Retinol is primarily stored in skeletal muscle.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2018

31. The primary storage site for Vitamin E in the animal body is:
(A) The liver
(B) Skeletal muscle
(C) Erythrocytes
(D) Adipose tissue

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fatty acids

2006

119. S-adenosylmethionine (SAMe) is commonly supplemented as a nutraceutical in dogs and cats primarily to support the function of the:
(A) Heart
(B) Kidneys
(C) Lungs
(D) Liver

2009

120. Arrange the following mechanistic steps by which antioxidant nutraceuticals mitigate lipid peroxidation in the correct sequence:
I. Interception of lipid peroxyl radical
II. Initiation of radical chain reaction by ROS
III. Formation of a stable nutraceutical radical
IV. Termination of the oxidative chain reaction
(A) II, I, III, IV
(B) I, II, IV, III
(C) II, III, I, IV
(D) I, III, II, IV

2019

121. The term "probiotic" specifically refers to:
(A) Non-digestible food ingredients that selectively stimulate beneficial bacteria
(B) Live microorganisms administered in adequate amounts to confer host health benefits
(C) Antimicrobial peptides secreted by lactic acid bacteria
(D) Inactivated yeast cultures used primarily for dietary palatability

2014

122. Which of the following constitutes a defining characteristic of an effective "prebiotic"?
(A) It must be a live, highly viable bacterial strain
(B) It must be easily digested and absorbed in the stomach
(C) Exhibiting a broad-spectrum bactericidal activity against pathogens
(D) Non-digestible fiber that selectively stimulates beneficial gut bacteria

2023

123. A "synbiotic" is formally defined as a product containing:
(A) A mixture of live probiotics and complementary prebiotics
(B) A synergistic combination of two different prebiotic fibers
(C) Multiple strains of probiotic bacteria
(D) Probiotics combined with antibiotics

2013

124. The most common bacterial genera utilized as probiotics in animal nutrition include:
(A) Escherichia and Salmonella
(B) Clostridium and Campylobacter
(C) Lactobacillus and Bifidobacterium
(D) Pseudomonas and Aeromonas

2023

125. The mechanism of competitive exclusion by probiotics in the gastrointestinal tract involves:
(A) Occupying mucosal binding sites to prevent pathogenic bacterial adhesion
(B) Directly paralyzing the host's intestinal smooth muscle
(C) Selectively absorbing various heavy metals from the luminal chyme
(D) Suppressing the host's systemic immune responses

NODIA

2002

126. Prebiotics such as fructo-oligosaccharides (FOS) are metabolized by hindgut microbes primarily to produce:
(A) Long-chain fatty acids used for energy storage
(B) Essential amino acids required for protein synthesis
(C) Bile acids
(D) Short-chain fatty acids (SCFAs) like acetate, propionate, and butyrate

2001

127. Which specific short-chain fatty acid, produced via prebiotic fermentation, serves as the primary energy source for colonic epithelial cells?
(A) Formate
(B) Butyrate
(C) Acetate
(D) Propionate

2012

128. How do probiotics generally lower the luminal pH of the gastrointestinal tract?
(A) By secreting hydrochloric acid
(B) By absorbing alkaline bicarbonate ions
(C) By producing organic acids such as lactic acid
(D) By synthesizing alkaline phosphatase

2005

129. Probiotics can exert direct antimicrobial effects against pathogens by synthesizing and secreting specific peptides known as:

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(A) Thiamine
(B) Riboflavin
(C) Pyridoxine
(D) Niacin

2021

43. Sweet clover disease in cattle, characterized by severe hemorrhages, is mechanistically caused by:
(A) Dicumarol acting as a Vitamin K antagonist
(B) A deficiency of dietary Vitamin C
(C) Bracken fern ingestion destroying thiamine
(D) High sulfur intake antagonizing copper

2004

44. Exudative diathesis in chicks is a combined deficiency syndrome of Vitamin E and which trace mineral?
(A) Copper
(B) Zinc
(C) Selenium
(D) Manganese

2002

45. The deficiency of which vitamin leads to macrocytic, megaloblastic anemia in animals due to the "methyl trap" hypothesis?
(A) Cyanocobalamin
(B) Pantothenic acid
(C) Pyridoxal phosphate
(D) Cholecalciferol

2011

46. Which clinical syndrome is considered the hallmark of Vitamin D deficiency in young growing animals?
(A) Osteomalacia
(B) Osteoporosis
(C) Chondrodysplasia
(D) Rickets

2010

47. Scurvy-like symptoms in farm animals are extremely rare; however, when observed in species lacking endogenous synthesis, they present primarily as:
(A) Generalized ataxia and pathological hyperreflexia
(B) Petechial hemorrhages and poor wound healing
(C) Hyperkeratosis and progressive night blindness
(D) Symmetrical alopecia and exudative dermatitis

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2016

48. Severe deficiency of Vitamin A in cattle frequently results in:
(A) Chronic diarrhea and exudative dermatitis
(B) Hemolytic anemia and oxidative stress
(C) Squamous metaplasia and night blindness
(D) Progressive nutritional muscular dystrophy

2001

49. Avidin, a glycoprotein found in raw egg whites, acts as a potent anti-vitamin by irreversibly binding to:
(A) Thiamine
(B) Riboflavin
(C) Niacin
(D) Biotin

2003

50. Consider the following statements regarding vitamin antagonists:
I. Dicumarol inhibits epoxide reductase.
II. Methotrexate acts as a folic acid antagonist.
III. Isoniazid commonly antagonizes Vitamin B_6.
IV. Pyrithiamine competitively inhibits thiamine kinase.
V. Amprolium functions as an antagonist of Vitamin C.
Which of the above statements are correct?
(A) I, II, III and V
(B) I, II, III and IV
(C) II, III, IV and V
(D) I, III, IV and V

2006

51. The biochemical mechanism of action of the antagonist methotrexate involves the competitive inhibition of:
(A) Thymidylate synthase
(B) Dihydrofolate reductase
(C) Serine hydroxymethyltransferase
(D) Methionine synthase

2015

52. Bracken fern poisoning in horses leads to severe neurological signs primarily because the plant contains:
(A) Dicumarol
(B) Thiaminase
(C) Phytate
(D) Oxalates

2002

53. Which drug acts as a competitive antagonist of Vitamin K, interfering with the formation of gamma-carboxyglutamate residues?
(A) Warfarin

(D) Lysyl oxidase

2010

75. The central biochemical function of selenium in animal tissues is closely linked to its incorporation into which unique amino acid?
(A) Selenocysteine
(B) Selenomethionine
(C) Selenotryptophan
(D) Selenoproline

2017

76. Which metalloenzyme strictly requires molybdenum for the conversion of hypoxanthine to uric acid?
(A) Xanthine oxidase
(B) Sulfite oxidase
(C) Aldehyde oxidase
(D) Tyrosinase

2017

77. Manganese serves as an essential cofactor for which mitochondrial enzyme involved in the detoxification of reactive oxygen species?
(A) Mitochondrial Mn Superoxide dismutase
(B) Cytosolic Cu/Zn Superoxide dismutase
(C) Catalase
(D) Glutathione reductase

2008

78. Iron is fundamentally incorporated into the heme functional group, which is central to the activity of:
(A) Hexokinase
(B) Pyruvate carboxylase
(C) Cytochrome P450 enzymes
(D) Alkaline phosphatase

2011

79. Iodine's sole known physiological function in domestic animals is its incorporation into:
(A) Calcitonin secretion
(B) Parathyroid hormone (PTH)
(C) Cortisol synthesis
(D) Thyroid hormones (T_4 and T_3)

2016

80. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Copper deficiency can lead to anemia in animals even if dietary iron is adequate.
Reason (R): Copper is required for the function of ceruloplasmin (ferroxidase I), which oxidizes Fe2+ to Fe3+ for transport by transferrin.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

2010

81. Which trace element is fundamentally required as an activator for arginase in the urea cycle?
(A) Copper
(B) Manganese
(C) Selenium
(D) Zinc

2013

82. Fluorine, considered a trace element, exhibits its primary physiological effect by:
(A) Activating pancreatic lipases
(B) Serving as a cofactor in glycolysis
(C) Enhancing the uptake of inorganic iodine by the thyroid gland
(D) Formation of acid-resistant fluoroapatite in bones and teeth

2017

83. The enzyme glutathione peroxidase depends on which trace element to reduce hydrogen peroxide to water?
(A) Selenium
(B) Zinc
(C) Copper
(D) Iron

2024

84. The biochemical function of chromium is highly associated with:
(A) Acting as a structural component of bone
(B) Modulating the synthesis of melatonin
(C) Potentiating the action of insulin via chromodulin
(D) Enhancing the binding of oxygen to myoglobin

2005

85. Parakeratosis in pigs, characterized by thick, hyperkeratinized skin lesions, is the classical sign of a deficiency in:
(A) Zinc
(B) Copper
(C) Iron
(D) Manganese

2011

86. Swayback (enzootic ataxia) in neonatal lambs is neurologically attributed to a maternal deficiency of:

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(C) It serves as the central atom in the porphyrin ring of hemoglobin
(D) It is strictly required for the initiation of muscle contraction

2014

65. The majority of the body's phosphorus is located in the skeleton; however, intracellular phosphorus is critical for:
(A) Maintaining extracellular fluid osmolality
(B) Facilitating the intestinal absorption of lipids
(C) Cross-linking collagen and elastin fibers
(D) The formation of high-energy phosphate bonds in ATP

2003

66. Sulfur in the animal body is primarily ingested and utilized in the form of:
(A) Inorganic elemental sulfur consumed via mineral supplements
(B) Gaseous hydrogen sulfide produced during ruminal fermentation
(C) Sulfur-containing amino acids such as methionine and cysteine
(D) Inorganic sulfates dissolved in the animal's drinking water

2002

67. Which of the following macro minerals is an essential structural component of the chlorophyll molecule, highlighting its physiological importance when animals consume forages?
(A) Calcium
(B) Magnesium
(C) Phosphorus
(D) Potassium

2004

68. The primary intracellular cation responsible for resting membrane potential in animal cells is:
(A) Potassium
(B) Sodium
(C) Calcium
(D) Magnesium

2010

69. Dietary requirements for micro minerals (trace elements) are typically expressed in which unit?
(A) Grams per kilogram of total dry matter (g/kg)
(B) Molar equivalents per liter of solvent (mEq/L)
(C) Percent of total diet by weight or volume (%)
(D) Milligrams per kilogram (mg/kg) or parts per million (ppm)

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2014

70. Match the essential trace elements in List I with their primary associated metalloenzyme or protein in List II:
List I: (Trace Elements)
P. Iron
Q. Zinc
R. Copper
S. Selenium
List II: (Associated Metalloenzyme/Protein)
1. Carbonic anhydrase
2. Glutathione peroxidase
3. Ceruloplasmin
4. Hemoglobin
(A) P-4, Q-1, R-3, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-4, R-1, S-3

2011

71. The biochemical function of magnesium frequently involves:
(A) Acting as the principal buffer in the extracellular fluid
(B) Transporting molecular oxygen within mammalian erythrocytes
(C) Synthesizing thyroid hormones
(D) Serving as an obligate cofactor for enzymes utilizing ATP

2008

72. Which micro mineral is fundamentally required for the structural stability of Vitamin B_{12}?
(A) Iron
(B) Cobalt
(C) Molybdenum
(D) Zinc

2019

73. Zinc plays a critical biochemical role as a structural component of which DNA-binding motifs?
(A) Leucine zippers
(B) Helix-turn-helix
(C) Zinc fingers
(D) Beta-barrels

2011

74. Copper is an essential cofactor for which enzyme responsible for the cross-linking of collagen and elastin?
(A) Prolyl hydroxylase
(B) Superoxide dismutase
(C) Cytochrome c oxidase

(B) Heparin
(C) Aspirin
(D) Streptokinase

2002

54. Amprolium is widely used as a coccidiostat in poultry due to its structural similarity and antagonistic action against:
(A) Niacin
(B) Riboflavin
(C) Thiamine
(D) Pyridoxine

2004

55. Raw fish in the diet of carnivores can cause Chastek paralysis due to the presence of an enzyme that destroys:
(A) Cyanocobalamin
(B) Folic acid
(C) Biotin
(D) Thiamine

2025

56. The administration of isoniazid for tuberculosis treatment often requires concurrent supplementation of which vitamin to prevent peripheral neuropathy?
(A) Vitamin B_1
(B) Vitamin B_{12}
(C) Vitamin B_6
(D) Vitamin C

2024

57. Sulfonamides act as anti-vitamins in bacteria by competitively inhibiting the incorporation of which compound into folic acid?
(A) Pteridine derivative
(B) Para-aminobenzoic acid
(C) L-Glutamic acid molecule
(D) Thiazole ring structure

2001

58. Aminopterin is an anti-vitamin that strictly interferes with the metabolism of:
(A) Pantothenic acid
(B) Biotin
(C) Riboflavin
(D) Folic acid

2015

59. What is the metabolic consequence of thiaminase ingestion in ruminants leading to cerebrocortical necrosis (polioencephalomalacia)?
(A) Impaired glucose oxidation leading to brain energy depletion
(B) Accumulation of toxic levels of methylmalonic acid
(C) Inhibition of blood coagulation
(D) Breakdown of myelin sheaths via catastrophic lipid peroxidation

2017

60. Arrange the following events leading to clinical thiamine deficiency upon ingesting a thiaminase-containing diet in the correct sequence:
I. Depletion of cellular TPP pools
II. Ingestion of active thiaminase
III. Impairment of alpha-ketoglutarate dehydrogenase
IV. Accumulation of pyruvate and lactate
V. Cleavage of dietary thiamine in the gut
(A) II, I, V, IV, III
(B) II, V, I, III, IV
(C) I, II, V, III, IV
(D) V, II, I, IV, III

2018

61. Minerals in animal nutrition are formally classified into macro and micro (trace) minerals based entirely on:
(A) Their relative concentrations in the diet and the animal body
(B) Their atomic weight
(C) Their specific solubility characteristics in acidic gastric juices
(D) Their ability to form complex coordinate bonds

2009

62. Which of the following is strictly categorized as a macro mineral in animal physiology?
(A) Copper
(B) Zinc
(C) Selenium
(D) Magnesium

2005

63. The primary physiological role of sodium, potassium, and chloride in the animal body is collectively related to:
(A) Bone mineralization
(B) Acid-base balance and osmotic regulation
(C) Connective tissue cross-linking
(D) Thyroid hormone synthesis

2001

64. Identify the INCORRECT statement regarding the foundational roles of calcium in animals.
(A) It is the primary mineral constituent of the skeleton
(B) It functions as an intracellular second messenger

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(A) Selenium
(B) Zinc
(C) Cobalt
(D) Copper

2002

87. "Piglet anemia" commonly occurs in newborn pigs raised indoors predominantly due to:
(A) Excessive bleeding from the umbilical cord
(B) Rapid growth and low iron content in sow's milk
(C) Inability to synthesize Vitamin K
(D) Zinc deficiency causing erythrocyte fragility

2011

88. Enzootic marasmus (Coast disease) in sheep and cattle is fundamentally caused by a deficiency of:
(A) Iodine
(B) Selenium
(C) Cobalt
(D) Molybdenum

2017

89. White muscle disease (nutritional muscular dystrophy) in calves and lambs results from a dual deficiency of:
(A) Calcium and Phosphorus
(B) Iron and Copper
(C) Zinc and Vitamin A
(D) Selenium and Vitamin E

2022

90. Consider the following statements regarding trace element deficiencies:
I. Manganese deficiency causes perosis (slipped tendon) in poultry.
II. Iodine deficiency leads to endemic goiter.
III. Copper deficiency causes achromotrichia (loss of hair pigment).
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2019

91. Steely wool in sheep is a manifestation of abnormal keratin cross-linking directly resulting from a deficiency of:
(A) Zinc
(B) Copper
(C) Sulfur
(D) Selenium

2002

92. Fluorosis in cattle, caused by chronic excessive ingestion of fluoride, clinically presents as:
(A) Severe hemorrhagic diarrhea and dehydration
(B) Mottled teeth, exostoses, and lameness
(C) Acute hepatic necrosis and liver failure
(D) Muscle convulsions and hypocalcemic tetany

2008

93. Blind staggers and alkali disease are classical toxicity syndromes associated with the accumulation of which trace element?
(A) Selenium
(B) Lead
(C) Molybdenum
(D) Arsenic

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2023

94. The condition "teart" in cattle, characterized by severe scouring (diarrhea), is induced by toxic levels of dietary:
(A) Copper
(B) Iron
(C) Molybdenum
(D) Iodine

2025

95. A classic sign of severe zinc deficiency in poultry is:
(A) Curled toe paralysis in young chicks
(B) Exudative diathesis and tissue edema
(C) Stargazing posture and polyneuritis
(D) Shortened long bones and poor feathering development

2017

96. Which trace mineral toxicity is notoriously species-specific, causing severe hemolytic crisis and jaundice primarily in sheep?
(A) Zinc
(B) Selenium
(C) Copper
(D) Iron

2018

97. The interaction between Selenium and Vitamin E is best described as:
(A) Mutually antagonistic interactions within the intestinal lumen
(B) Synergistic function in cellular antioxidant defense systems
(C) Competition for specific transport proteins in the bloodstream
(D) Independent activity on completely separate metabolic pathways

2001

98. In ruminant nutrition, a critical three-way mineral interaction that strongly limits copper bioavailability is the:
(A) Calcium-Phosphorus-Magnesium axis
(B) Iron-Zinc-Manganese axis
(C) Sodium-Potassium-Chloride axis
(D) Copper-Molybdenum-Sulfur axis

2007

99. The formation of thiomolybdates in the rumen is directly responsible for:
(A) Binding copper and inducing secondary copper deficiency
(B) Enhancing selenium absorption
(C) Facilitating the absorption of Vitamin B_{12}
(D) Facilitating detoxification of dietary heavy metals

2008

100. Consider the following statements concerning mineral-mineral interactions:
I. High dietary calcium can reduce zinc absorption, exacerbating parakeratosis.
II. Excess dietary iron strongly inhibits copper absorption.
III. Cadmium toxicity can be partially alleviated by zinc supplementation.
IV. High phosphorus levels enhance the absorption of magnesium.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2006

101. Excess phytate in plant-based diets primarily reduces the bioavailability of which critical minerals in monogastric animals?
(A) Calcium, Phosphorus, and Zinc
(B) Sodium and Potassium
(C) Selenium and Iodine
(D) Cobalt and Molybdenum

2002

102. An excessive intake of dietary sulfur in ruminants can precipitate polioencephalomalacia due to:
(A) Direct antagonism of thiamine synthesis
(B) Insoluble chelation of dietary calcium in the gut
(C) Rapid depletion of blood oxygen
(D) Production of toxic hydrogen sulfide gas in the rumen

2003

103. Ascorbic acid significantly enhances the intestinal absorption of which specific mineral by maintaining it in a reduced state?
(A) Calcium
(B) Iron
(C) Zinc
(D) Magnesium

2012

104. High dietary potassium strongly interferes with the absorption of which macro mineral, leading to grass tetany in grazing ruminants?
(A) Calcium
(B) Phosphorus
(C) Magnesium
(D) Sodium

2009

105. The physiological interaction between Calcium, Phosphorus, and Vitamin D is essential for:
(A) Erythropoiesis
(B) Regulation of blood coagulation
(C) Maintenance of the resting membrane potential
(D) Normal bone mineralization and homeostasis

2022

106. Which metallothionein-inducing trace element most notably antagonizes copper absorption at the level of the intestinal enterocyte?
(A) Iron
(B) Selenium
(C) Zinc
(D) Cobalt

2025

107. The excessive feeding of brassica forages can inhibit iodine utilization due to the presence of:
(A) Phytic acid
(B) Glucosinolates and thiocyanates
(C) Insoluble oxalates
(D) Condensed tannins

2007

108. Excess dietary calcium in growing poultry often precipitates a deficiency of which trace mineral by forming insoluble complexes?
(A) Manganese
(B) Selenium
(C) Iodine
(D) Copper

2003

109. Nutraceuticals are formally defined in animal health as:
(A) Synthetic pharmacological drugs used for

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clinical disease treatment
(B) Genetically modified organisms intended for food
(C) Inert non-nutritive fillers used during industrial feed formulation
(D) Food or food components providing health benefits and disease prevention

2016

110. Consider the following statements regarding nutraceuticals:
I. Phytochemicals such as flavonoids function primarily as antioxidants.
II. Omega-3 fatty acids exert significant anti-inflammatory effects.
III. Carotenoids are often nutrients but also serve as health-promoting pigments.
IV. Glucosamine is utilized for supporting articular cartilage health.
V. Polyphenols improve gastrointestinal mucosal barrier function.
Which of the above statement(s) are correct?
(A) I, II and IV
(B) I, III and V
(C) II, IV and V
(D) All of the statements are correct

2002

111. Omega-3 polyunsaturated fatty acids (PUFAs) act as nutraceuticals primarily by:
(A) Increasing the synthesis of pro-inflammatory Series 2 prostaglandins
(B) Directly inhibiting protein synthesis in immune cells
(C) Replacing cholesterol molecules within cellular membranes
(D) Precursors for less inflammatory Series 3 prostaglandins and resolvins

2022

112. The active component curcumin, utilized in animal nutraceuticals for its anti-inflammatory properties, is derived from:
(A) Garlic
(B) Turmeric
(C) Ginger
(D) Green tea

2018

113. In veterinary nutraceuticals, chondroitin sulfate is most frequently co-administered with glucosamine for the management of:
(A) Congestive heart failure
(B) Chronic kidney disease
(C) Osteoarthritis
(D) Diabetes mellitus

NODIA

2016

114. The beneficial effects of plant polyphenols in animal diets are largely attributed to their capacity to:
(A) Provide a primary energy source comparable to carbohydrates
(B) Function as structural components of the extracellular matrix
(C) Substitute for essential amino acids
(D) Act as free radical scavengers and modulate cell signaling

2005

115. Allicin is a sulfur-containing nutraceutical compound renowned for its antimicrobial properties and is extracted from:
(A) Garlic
(B) Turgano
(C) Aloe vera
(D) Echinacea

2021

116. Which of the following best represents the metabolic significance of incorporating L-carnitine as a nutraceutical in animal diets?
(A) Acting as a primary metabolic substrate for hepatic gluconeogenesis
(B) Mitochondrial transport of long-chain fatty acids for beta-oxidation
(C) Enhancing the microbial ruminal digestion of dietary cellulose
(D) Inhibiting the process of lipid peroxidation in circulating blood

2022

117. Phytosterols are occasionally used in animal diets specifically to:
(A) Competitive inhibition of intestinal cholesterol absorption
(B) Stimulate rapid muscle hypertrophy
(C) Increase bone mineral density
(D) Treating various infectious gastrointestinal diarrheal diseases

2008

118. Which statement correctly identifies a unique property of beta-glucans used as nutraceuticals?
(A) They are rapidly absorbed in the stomach as simple sugars
(B) Being toxic to certain species of monogastric animals
(C) Modulating the innate immune system via macrophage activation
(D) They inhibit the production of short-chain

2006

32. What dictates the classification of phylloquinone and menaquinone as forms of Vitamin K?
(A) Presence of a cobalt atom
(B) A substituted beta-ionone ring
(C) Variation in the attached isoprenoid side chain
(D) The specific stereochemistry of the enediol group

2013

33. The most biologically active vitamer of Vitamin E is:
(A) Beta-tocopherol
(B) Alpha-tocopherol
(C) Gamma-tocopherol
(D) Delta-tocotrienol

2012

34. Which of the following statements correctly identifies the transport of newly absorbed Vitamin E?
(A) It is transported via the portal vein bound to plasma albumin proteins
(B) It travels bound to specific tocopherol-binding proteins in the plasma
(C) It is conjugated with glucuronic acid for renal and hepatic transport
(D) Incorporation into chylomicrons for transport via the lymphatic system

2009

35. Vitamin A acts mechanistically similar to a steroid hormone because it:
(A) Binds to nuclear receptors to modulate transcription of specific genes
(B) Binds directly to cell surface G-protein coupled receptors
(C) Activates adenylate cyclase to produce cAMP
(D) Induces the rapid opening of specific intracellular calcium ion channels

2009

36. In ruminants, under optimal conditions, Vitamin K supplementation is generally unnecessary due to:
(A) Extensive hepatic storage from birth
(B) Absence of blood coagulation pathways
(C) Synthesis by ruminal microbiota
(D) Endogenous synthesis from short-chain fatty acids

2012

37. Curled toe paralysis in growing chicks is a classic clinical manifestation of which vitamin deficiency?
(A) Riboflavin
(B) Thiamine
(C) Niacin
(D) Pantothenic acid

2013

38. The presentation of polyneuritis (stargazing posture) in poultry is directly attributed to a deficiency of:
(A) Vitamin B_6 (Pyridoxine)
(B) Vitamin B_{12} (Cyanocobalamin)
(C) Vitamin C (Ascorbic acid)
(D) Vitamin B_1 (Thiamine)

2012

39. Encephalomalacia in poultry, commonly referred to as "crazy chick disease," is a prominent deficiency symptom of:
(A) Vitamin A
(B) Vitamin E
(C) Vitamin D
(D) Vitamin K

2018

40. Consider the following statements regarding vitamin toxicities:
I. Hypervitaminosis A can lead to bone deformities and teratogenesis.
II. Vitamin C toxicity commonly causes severe hepatic necrosis in animals.
III. Hypervitaminosis D leads to soft tissue calcification.
IV. High doses of Vitamin K_3 (menadione) can cause hemolytic anemia in some species.
Which of the above statements are correct?
(A) I and II
(B) II and IV
(C) I, III and IV
(D) II

2003

41. Goose-stepping in swine is a classical neurological symptom associated with a deficiency of:
(A) Biotin (Vitamin B_7)
(B) Pantothenic acid
(C) Folate (Vitamin B_9)
(D) Cyanocobalamin

2006

42. Black tongue disease in dogs is the clinical equivalent of human pellagra and is caused by a deficiency of:

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(A) Cytokines
(B) Enterotoxins
(C) Lysozymes
(D) Bacteriocins

2022

130. Match the gut health terminology in List I with its correct mechanism or example in List II:
List I: (Gut Health Terminology)
P. Probiotic
Q. Prebiotic
R. Postbiotic
S. Synbiotic
List II: (Mechanism or Example)
1. Mannan-oligosaccharides (MOS)
2. Enterococcus faecium + Inulin
3. Secreted soluble factors/metabolites from bacteria
4. Bacillus subtilis spores
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

2024

131. In poultry production, competitive exclusion products are administered to day-old chicks primarily to prevent colonization by:
(A) Avian influenza virus
(B) Salmonella species
(C) Coccidia
(D) Aspergillus species

2002

132. Prebiotics containing mannan-oligosaccharides (MOS), typically derived from the cell wall of Saccharomyces cerevisiae, function predominantly by:
(A) Fermenting rapidly to significantly lower the local cecal pH
(B) Acting as decoy receptors for Type-1 fimbriae of pathogenic bacteria
(C) Directly killing gram-positive bacteria
(D) Enhancing gastric acid secretion

2017

133. Chemically, hormones are broadly classified into which three main groups?
(A) Peptides/Proteins, Steroids, and Amino acid derivatives
(B) Carbohydrates, Lipids, and Nucleic acids
(C) Phospholipids, Glycolipids, and Sphingolipids
(D) Vitamins, Minerals, and Eicosanoids

2025

134. Which of the following is strictly a steroid hormone?
(A) Epinephrine
(B) Insulin
(C) Aldosterone
(D) Thyroxine

2017

135. All naturally occurring steroid hormones are ultimately synthesized from a common precursor known as:
(A) Tyrosine
(B) Arachidonic acid
(C) Pro-opiomelanocortin (POMC)
(D) Cholesterol

2017

136. Amine hormones, such as catecholamines and thyroid hormones, are derived primarily from which amino acid?
(A) Tryptophan
(B) Glutamate
(C) Tyrosine
(D) Histidine

2015

137. Eicosanoids, a class of local signaling hormones including prostaglandins, are synthesized from:
(A) Linolenic acid
(B) Arachidonic acid
(C) Palmitic acid
(D) Cholesterol

2024

138. The biosynthesis of peptide hormones inherently involves:
(A) Direct enzymatic synthesis in the smooth endoplasmic reticulum
(B) Cleavage of cholesterol side chains in the mitochondria
(C) Active iodine organification within the thyroid follicular cells
(D) Ribosomal translation into a preprohormone via mRNA transcription

2002

139. The rate-limiting step in the biosynthesis of all steroid hormones is the conversion of cholesterol to:
(A) Pregnenolone
(B) Progesterone
(C) Dehydroepiandrosterone
(D) Cortisol

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2016

140. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Peptide hormones generally cannot cross the plasma membrane to enter target cells.
Reason (R): Peptide hormones are highly lipophilic and immediately partition into the lipid bilayer.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

2018

141. The specific enzyme responsible for the conversion of testosterone to the more potent dihydrotestosterone (DHT) is:
(A) 5-alpha-reductase
(B) Aromatase
(C) 21-hydroxylase
(D) 11-beta-hydroxylase

2013

142. Which enzyme strictly catalyzes the conversion of androgens to estrogens?
(A) Desmolase
(B) 17-alpha-hydroxylase
(C) Aldosterone synthase
(D) Aromatase

2021

143. Melatonin is an amine hormone synthesized in the pineal gland. Its primary biochemical precursor is:
(A) Tyrosine
(B) Tryptophan
(C) Phenylalanine
(D) Histidine

2005

144. In the biosynthesis of catecholamines, identify the correct sequence of intermediates from tyrosine:
(A) Tyrosine → Dopamine → DOPA → Norepinephrine → Epinephrine
(B) Tyrosine → DOPA → Dopamine → Norepinephrine → Epinephrine
(C) Tyrosine → Norepinephrine → DOPA → Dopamine → Epinephrine
(D) Tyrosine → DOPA → Norepinephrine → Dopamine → Epinephrine

2005

145. Hormone receptors are broadly classified based on their cellular location into:
(A) Secretory and non-secretory receptors
(B) Primary and secondary hormone-binding receptor proteins
(C) Ionotropic and catalytic receptors exclusively
(D) Membrane-bound and intracellular (cytosolic or nuclear) receptors

2012

146. Which of the following hormones classically binds to a plasma membrane receptor?
(A) Cortisol
(B) Triiodothyronine (T_3)
(C) Glucagon
(D) Progesterone

2022

147. G-protein coupled receptors (GPCRs), a major class of membrane receptors, are characterized by:
(A) Having a single transmembrane domain
(B) Spanning the plasma membrane seven times
(C) Possessing intrinsic tyrosine kinase activity
(D) Functioning as direct ligand-gated ion channels

NODIA

2006

148. The insulin receptor structurally belongs to which family of membrane receptors?
(A) Receptor tyrosine kinases
(B) G-protein coupled receptors
(C) Cytokine receptors
(D) Ligand-gated ion channels

2025

149. Nuclear receptors typically function biochemically as:
(A) Ion channels
(B) Specialized second messenger generators
(C) Transmembrane pumps
(D) Ligand-activated transcription factors

2001

150. Consider the following statements regarding intracellular receptors:
I. They typically bind lipophilic hormones.
II. Unliganded steroid receptors are often bound to heat shock proteins.
III. They elicit cellular responses within milliseconds.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III

(D) I, II and III

2014

151. The DNA sequence to which a hormone-receptor complex binds to regulate transcription is termed the:
(A) TATA box
(B) Pribnow box
(C) Ribosome binding site
(D) Hormone response element (HRE)

2014

152. Cytokine receptors (e.g., Growth Hormone receptor) lack intrinsic kinase activity and instead recruit which intracellular kinases upon ligand binding?
(A) MAP kinases
(B) JAK (Janus kinases)
(C) Protein kinase A
(D) Phospholipase C

2019

153. Upon binding its ligand, a typical steroid receptor undergoes a conformational change resulting in:
(A) Rapid degradation of the receptor
(B) Cleavage of the receptor into two active fragments
(C) Dimerization and nuclear translocation
(D) Export from the nucleus to the cytosol

2012

154. Thyroid hormone receptors (TRs) are unique compared to typical steroid hormone receptors because they:
(A) Are bound to the plasma membrane and activate adenylyl cyclase
(B) Binding exclusively to nuclear RNA molecules instead of genomic DNA
(C) Require a second messenger cascade for activation
(D) Nuclear residence even in unliganded states, often acting as repressors

2012

155. Identifying the INCORRECT pair of receptor types and their domains.
(A) Ion channel receptor – Intracellular GTP-binding domain
(B) GPCR – 7 transmembrane alpha-helices
(C) Receptor Tyrosine Kinase – Intracellular kinase domain
(D) Steroid Receptor – DNA-binding domain with zinc fingers

2022

156. The domain of a nuclear receptor that determines the specific gene to be targeted is the:
(A) Ligand-binding domain (LBD)
(B) DNA-binding domain (DBD)
(C) Activation function 1 (AF-1) domain
(D) Hinge region

2005

157. Which enzyme is responsible for synthesizing the second messenger cyclic AMP (cAMP) from ATP?
(A) Adenylate cyclase
(B) Phosphodiesterase
(C) Guanylate cyclase
(D) Phospholipase C

2009

158. The principal intracellular target activated by elevated levels of cAMP is:
(A) Protein Kinase C (PKC)
(B) Calcium-calmodulin dependent kinase
(C) Protein Kinase A (PKA)
(D) MAP kinase

2015

159. In the IP3/DAG second messenger pathway, which membrane lipid is cleaved by Phospholipase C?
(A) Neutral Phosphatidylcholine
(B) Structural Sphingomyelin
(C) Membrane Phosphatidylethanolamine
(D) Phosphatidylinositol 4,5-bisphosphate (PIP2)

2004

160. Consider the following statements concerning the IP3/DAG pathway:
I. IP3 is highly water-soluble and diffuses into the cytosol.
II. DAG remains in the plasma membrane.
III. IP3 causes the release of calcium from the endoplasmic reticulum.
IV. DAG directly inhibits Protein Kinase C.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2015

161. Cyclic GMP (cGMP) acts as a second messenger primarily in response to which hormone?
(A) Epinephrine
(B) Atrial Natriuretic Peptide
(C) Glucagon

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(C) Increase both blood calcium and phosphate levels
(D) Stimulate the deposition of calcium into bone

2017

230. PTH is secreted by the chief cells of the parathyroid gland in direct response to:
(A) Hypercalcemia
(B) Hypocalcemia
(C) Hyperglycemia
(D) Hyponatremia

2016

231. Calcitonin, which acts to lower blood calcium levels, is synthesized and secreted by the:
(A) Parathyroid chief cells
(B) Thyroid parafollicular (C) cells
(C) Adrenal zona glomerulosa
(D) Renal proximal tubule cells

2011

232. In the kidney, PTH strongly stimulates the expression of which enzyme to produce the active form of Vitamin D (1,25-dihydroxycholecalciferol)?
(A) 25-hydroxylase
(B) 24-hydroxylase
(C) Aromatase
(D) 1-alpha-hydroxylase

2022

233. The principal action of 1,25-dihydroxycholecalciferol (active Vitamin D) in calcium homeostasis is to:
(A) Increasing intestinal absorption of calcium and phosphorus
(B) Inhibit osteoclast activity
(C) Increase renal excretion of calcium
(D) Stimulating the rapid systemic release of calcitonit

2006

234. At the level of the bone, PTH directly acts on osteoblasts, which subsequently secrete factors (e.g., RANKL) that stimulate the activity of:
(A) Chondrocytes
(B) Osteocytes
(C) Fibroblasts
(D) Osteoclasts

2022

235. What is the specific effect of PTH on renal phosphate handling?
(A) It drastically increases phosphate reabsorption
(B) It inhibits phosphate reabsorption, causing phosphaturia
(C) It has no effect on phosphate
(D) It actively pumps phosphate into the blood from the tubule lumen

2007

236. The calcium-sensing receptor (CaSR) on the parathyroid gland belongs to which receptor class?
(A) Tyrosine kinase receptor
(B) G-protein coupled receptor (GPCR)
(C) Intracellular nuclear receptor
(D) Ligand-gated ion channel

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2001

237. The active form of Vitamin D exerts its biological effects in the intestine primarily by:
(A) Using a nuclear receptor to upregulate calcium-binding proteins
(B) Opening specific mechanosensitive calcium channels in enterocytes
(C) Activating adenylate cyclase in enterocytes
(D) Stimulating tight junction breakdown to allow paracellular flow

2003

238. Calcitonin regulates calcium strictly by:
(A) Enhancing intestinal calcium absorption
(B) Increasing PTH secretion
(C) Enhancing the renal reabsorption of filtered calcium
(D) Inhibiting osteoclast-mediated bone resorption

2025

239. The interplay between PTH and Vitamin D is essential because:
(A) PTH lowers blood calcium while Vitamin D acts to raise it
(B) PTH inhibits Vitamin D synthesis
(C) Vitamin D stimulates the excretion of PTH
(D) Working synergistically to maintain extracellular calcium levels

2006

240. Select the correct physiological sequence in response to acute hypocalcemia:
I. Increased bone resorption and renal calcium reabsorption
II. Release of Parathyroid Hormone (PTH)
III. Activation of Calcium-Sensing Receptors (decreased binding)
IV. Restoration of normal blood calcium
V. Stimulation of 1-alpha-hydroxylase in the kidney
(A) III, II, V, I, IV

2014

173. The primary target tissue of Corticotropin-Releasing Hormone (CRH) is the:
(A) Adrenal cortex
(B) Corticotroph cells of the anterior pituitary
(C) Hypothalamic paraventricular nucleus
(D) Renal collecting duct epithelial cells

2016

174. A classical negative feedback loop in the HPA axis involves which hormone inhibiting the release of CRH and ACTH?
(A) Epinephrine
(B) Aldosterone
(C) Cortisol
(D) Thyroxine

2023

175. Pulsatile secretion is an absolute physiological requirement for the normal functional efficacy of which hypothalamic hormone?
(A) TRH
(B) Somatostatin
(C) CRH
(D) GnRH

2009

176. Which neurohormones are synthesized in the paraventricular and supraoptic nuclei of the hypothalamus but secreted from the posterior pituitary?
(A) FSH and LH
(B) GH and Prolactin
(C) Oxytocin and ADH
(D) TRH and CRH

2010

177. If the pituitary stalk (infundibulum) is completely severed, the secretion of most anterior pituitary hormones decreases. However, the secretion of one hormone dramatically increases. Which one?
(A) ACTH
(B) Prolactin
(C) Growth Hormone
(D) TSH

2015

178. TRH stimulates the release of TSH; however, it is also a potent stimulator for the release of which other anterior pituitary hormone?
(A) Prolactin
(B) Growth Hormone
(C) Follicle-Stimulating Hormone
(D) Adrenocorticotropic Hormone

2002

179. The ultra-short loop feedback mechanism in neuroendocrinology refers to:
(A) Pituitary hormones inhibiting the releasing hypothalamus
(B) A peripheral target gland hormone inhibiting the pituitary
(C) A peripheral target gland hormone inhibiting another peripheral gland
(D) Hypothalamic hormone inhibiting its own synthesis and secretion

2024

180. Select the correct functional sequence describing the Hypothalamic-Pituitary-Thyroid (HPT) axis:
(A) TSH release → Hypothalamus → TRH release → Thyroid gland → T_3/T_4
(B) TRH release → Anterior pituitary → TSH release → Thyroid gland → T_3/T_4
(C) Anterior pituitary → TRH release → Hypothalamus → TSH release → Thyroid gland → T_3/T_4
(D) T_3/T_4 release → Hypothalamus → TSH release → Anterior pituitary → TRH

2010

181. Growth Hormone (Somatotropin) exerts much of its growth-promoting effect on skeletal and soft tissues indirectly via the production of:
(A) Epidermal Growth Factor proteins
(B) Fibroblast Growth Factor molecules
(C) Nerve Growth Factor
(D) Insulin-like Growth Factor-1 (IGF-1)

2019

182. Which metabolic effect is directly attributable to the action of Growth Hormone in adult animals?
(A) Increased glucose uptake by skeletal muscle
(B) Enhanced lipolysis in adipose tissue
(C) Stimulation of glycogen synthesis in the liver
(D) Suppression of protein synthesis

2009

183. The glycoprotein hormones of the anterior pituitary (TSH, FSH, LH) share a common structural feature, which is:
(A) An identical beta subunit
(B) They are all single polypeptide chains
(C) An identical alpha subunit
(D) They contain a high concentration of zinc

2017

184. The primary action of Adrenocorticotropic Hormone (ACTH) is to stimulate the adrenal cortex to secrete:

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(D) Cortisol

2005

162. Intracellular calcium exerts many of its second messenger effects by binding to which ubiquitous regulatory protein?
(A) Troponin C
(B) Calmodulin
(C) Calsequestrin
(D) Calbindin

2001

163. How is the cAMP second messenger signal typically terminated within the cell?
(A) Hydrolysis to 5'-AMP by phosphodiesterase
(B) Conversion back to ATP by adenylate cyclase
(C) Export of cAMP out of the cell
(D) Degradation of cAMP by monoamine oxidase

2005

164. The activation of a Gs (stimulatory G protein) by a hormone-receptor complex specifically results in the:
(A) Inhibition of adenylate cyclase
(B) Activation of potassium channels
(C) Activation of adenylate cyclase
(D) Inhibition of phospholipase C

2010

165. The kinase cascade most frequently initiated by receptor tyrosine kinases, leading to cell division and growth, is the:
(A) JAK-STAT signaling pathway
(B) Intracellular cAMP-PKA pathway
(C) IP3-Calcium signaling pathway
(D) Ras-MAPK (Mitogen-Activated Protein Kinase) pathway

2006

166. Cholera toxin causes massive fluid loss by persistently activating which component of the second messenger system?
(A) Gi protein alpha subunit
(B) Phospholipase C
(C) Gs protein alpha subunit
(D) Protein Kinase C

2001

167. Which of the following best describes the role of Diacylglycerol (DAG) in cellular signaling?
(A) It opens calcium channels on the sarcoplasmic reticulum
(B) It activates Protein Kinase C (PKC) in the presence of calcium
(C) It acts as a direct transcription factor in the nucleus
(D) It inhibits adenylyl cyclase

2015

168. In phototransduction, the reduction in levels of which second messenger leads to the closure of sodium channels?
(A) cAMP
(B) IP3
(C) Calcium
(D) cGMP

2002

169. The hypothalamic-pituitary axis is anatomically and functionally connected via two main pathways. The anterior pituitary is controlled by the hypothalamus primarily through:
(A) The hypophyseal portal vascular system
(B) Direct neural axonal connections
(C) Diffusion through cerebrospinal fluid
(D) The lymphatic system

2024

170. Consider the following hypothalamic hormones:
I. Thyrotropin-Releasing Hormone (TRH)
II. Corticotropin-Releasing Hormone (CRH)
III. Growth Hormone-Releasing Hormone (GHRH)
IV. Luteinizing Hormone (LH)
V. Gonadotropin-Releasing Hormone (GnRH)
Which of the above statement(s) are correct regarding hormones synthesized by the hypothalamus?
(A) I, II, III and V
(B) I, II, IV and V
(C) II, III, IV and V
(D) I, III, IV and V

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2013

171. Which hypothalamic hormone is unique because its primary physiological action is to chronically inhibit the secretion of its target pituitary hormone?
(A) Dopamine
(B) Thyrotropin-RH
(C) Corticotropin-RH
(D) Gonadotropin-RH

2011

172. Somatostatin, released by the hypothalamus, functions specifically to inhibit the secretion of:
(A) ACTH secretion
(B) Prolactin release
(C) Gonadotropins (FSH/LH)
(D) Growth Hormone and TSH

proximal tubule
(C) Inhibiting systemic aldosterone hormone secretion
(D) Inserting aquaporin-2 channels into collecting duct apical membranes

2008

196. The two classical physiological roles of oxytocin in mammalian reproduction are:
(A) Ovarian follicle growth and ovulation
(B) Spermatogenesis and testosterone secretion
(C) Uterine contraction during parturition and milk let-down
(D) Maintenance of pregnancy and specific maternal behavior

2024

197. Oxytocin initiates milk ejection by specifically contracting which cells in the mammary gland?
(A) Alveolar secretory cells
(B) Myoepithelial cells
(C) Ductular epithelial cells
(D) Adipocytes

2012

198. Central Diabetes Insipidus in animals is characterized by polyuria and polydipsia, fundamentally caused by:
(A) A lack of sensitivity of the kidneys to ADH
(B) Autoimmune destruction of pancreatic beta cells
(C) Pathological excessive production of aldosterone
(D) Absolute deficiency in ADH hormone synthesis or release

2009

199. Structurally, both oxytocin and vasopressin are:
(A) Nonapeptides
(B) Glycoproteins
(C) Steroid hormones
(D) Biogenic amines

2009

200. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Administration of exogenous ADH successfully treats nephrogenic diabetes insipidus.
Reason (R): Nephrogenic diabetes insipidus is caused by defective ADH receptors (V_2) or aquaporin channels in the kidney, not by a lack of hormone.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

2002

201. Which specific receptor subtype strictly mediates the vasoconstrictor effects of Vasopressin on vascular smooth muscle?
(A) V_1 receptor
(B) V_2 receptor
(C) V_3 receptor
(D) AT_1 receptor

2003

202. The carrier proteins responsible for transporting oxytocin and vasopressin down the axon to the posterior pituitary are called:
(A) Transcortins
(B) Globulins
(C) Chromogranins
(D) Neurophysins

2003

203. Severe hemorrhage (hypovolemia) results in the massive secretion of which posterior pituitary hormone to help restore blood pressure?
(A) Oxytocin
(B) Vasopressin
(C) Prolactin
(D) Somatostatin

2012

204. During the Ferguson reflex of parturition, cervical dilation triggers sensory nerves that stimulate the release of:
(A) Progesterone
(B) Relaxin
(C) Oxytocin
(D) Prostaglandin F_2-alpha

2005

205. The biosynthesis of thyroid hormones is entirely unique because it occurs:
(A) Solely within the mitochondria of parafollicular cells
(B) In the bloodstream bound to albumin
(C) Exclusively within the lumen of the smooth endoplasmic reticulum
(D) Extracellularly, within the colloid of the thyroid follicle

2018

206. Which enzyme is responsible for the oxidation of iodide, iodination of tyrosine residues, and coupling of iodotyrosines in the thyroid gland?

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(A) Mineralocorticoids such as aldosterone
(B) Catecholamines such as epinephrine
(C) Androgens exclusively
(D) Glucocorticoids such as cortisol and corticosterone

2016

185. In males, Luteinizing Hormone (LH) strictly targets which cells to stimulate testosterone production?
(A) Leydig cells
(B) Sertoli cells
(C) Spermatogonia
(D) Epididymal epithelial cells

2014

186. Follicle-Stimulating Hormone (FSH) in females primarily functions to:
(A) Trigger the specific process of ovulation directly
(B) Development and maturation of ovarian follicles
(C) Maintain the corpus luteum during pregnancy
(D) Stimulate uterine smooth muscle contraction

2022

187. Prolactin in mammals is fundamentally responsible for:
(A) Initiating and maintaining milk production (lactogenesis)
(B) Inducing milk let-down
(C) Stimulating overall body growth
(D) Regulating the animal's basal metabolic rate

2019

188. ACTH is synthesized in corticotrophs as a large precursor molecule known as:
(A) Preproglucagon
(B) Thyroglobulin
(C) Pro-opiomelanocortin
(D) Somatomedin-C

2010

189. Which of the following states would most directly stimulate the secretion of Growth Hormone?
(A) Hyperglycemia
(B) High plasma levels of IGF-1
(C) Somatostatin administration
(D) Hypoglycemia and fasting

2021

190. Match the Anterior Pituitary hormone in List I with its predominant target cell or tissue in List II:
List I: (Anterior Pituitary Hormone)
P. TSH
Q. ACTH
R. FSH
S. Prolactin
List II: (Target Cell/Tissue)
1. Zona fasciculata
2. Mammary alveolar epithelium
3. Granulosa cells
4. Thyroid follicular cells
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-4, S-2

2022

191. A hypersecreting tumor of somatotrophs occurring in an animal after the closure of the epiphyseal plates results clinically in:
(A) Gigantism
(B) Acromegaly
(C) Dwarfism
(D) Cushing's disease

2014

192. Cleavage of the POMC precursor peptide yields ACTH and which other biologically active peptide?
(A) Oxytocin
(B) Beta-endorphin
(C) Vasopressin
(D) Growth Hormone

NODIA

2023

193. The posterior pituitary (neurohypophysis) differs from the anterior pituitary in that it:
(A) Storing and releasing hormones synthesized in the hypothalamus
(B) Synthesizes and secretes releasing hormones
(C) Lacking a functional direct arterial blood supply entirely
(D) Is under the control of releasing factors via portal circulation

2024

194. The primary physiological trigger for the release of Antidiuretic Hormone (ADH/Vasopressin) is:
(A) A decrease in plasma osmolality
(B) An increase in blood pressure
(C) An increase in plasma osmolality
(D) Hyperglycemia

2012

195. At the level of the kidney, ADH primarily increases water reabsorption by:
(A) Increasing the glomerular filtration rate
(B) Stimulating sodium reabsorption in the

(B) Weight loss, polyphagia, and tachycardia
(C) Severe watery diarrhea and neurological hyperexcitability
(D) Muscle tremors and hyperthermia

2021

219. Hyperthyroidism is a very common endocrine disorder in older cats. The most consistent clinical signs include:
(A) Profound weight gain and lethargy
(B) Weight loss despite a ravenous appetite (polyphagia)
(C) Bradycardia and hypothermia
(D) Severe bilateral and symmetrical endocrine alopecia

2014

220. Myxedema, a feature of severe hypothyroidism, involves the accumulation of which substances in the dermal tissues?
(A) Neutral lipids and extracellular cholesterol deposits
(B) Glycosaminoglycans like hyaluronic acid and chondroitin sulfate
(C) Calcium phosphate crystals
(D) Glycogen deposits

2019

221. Primary hypothyroidism is biochemically characterized by which hormone profile?
(A) Low T_4, High TSH
(B) Low T_4, Low TSH
(C) High T_4, Low TSH
(D) High T_4, High TSH

2010

222. Congenital hypothyroidism resulting from iodine deficiency during pregnancy leads to a severe developmental syndrome in offspring known as:
(A) Acromegaly
(B) Addison's disease
(C) Rickets
(D) Cretinism

2013

223. Feline hyperthyroidism typically results from:
(A) Benign adenomatous hyperplasia (adenoma) of the thyroid gland
(B) Autoimmune destruction of the thyroid
(C) A functional pituitary tumor secreting massive levels of TSH
(D) Iodine deficiency

2008

224. Which pharmacological agent is most commonly used to medically manage hyperthyroidism in cats by inhibiting thyroid peroxidase?
(A) Levothyroxine
(B) Prednisolone
(C) Trilostane
(D) Methimazole

2010

225. A dog is diagnosed with secondary hypothyroidism. What is the expected locus of the functional defect?
(A) Functional defects within the thyroid gland itself
(B) Peripheral tissue resistance to T_3
(C) Accelerated hepatic metabolism of T_4
(D) Anterior pituitary failure to secrete TSH

2008

226. In animals with hyperthyroidism, why does tachycardia and increased cardiac output occur?
(A) T_3 upregulates myocardial beta-adrenergic receptors
(B) T_3 directly blocks parasympathetic ganglia
(C) T_3 downregulates calcium channels in the SA node
(D) T_3 inhibits the endogenous synthesis of epinephrine

2024

227. Altered basal metabolic rate (BMR) in hyperthyroidism is closely linked to increased uncoupling of oxidative phosphorylation, generating excess:
(A) ATP
(B) Heat
(C) Lactic acid
(D) Glycogen

NODIA

2009

228. Thyroid hormones alter lipid metabolism. In hypothyroidism, which common biochemical finding is observed in the blood profile?
(A) Hypercholesterolemia
(B) Hypocholesterolemia
(C) Severe hypoglycemia
(D) Hypoproteinemia

2017

229. The main physiological function of Parathyroid Hormone (PTH) is to:
(A) Decrease total and ionized blood calcium levels
(B) Increase blood calcium and decrease blood phosphate

(A) Tyrosine hydroxylase
(B) Iodothyronine deiodinase
(C) Thyroid peroxidase (TPO)
(D) Steroid aromatase

2014

207. In the thyroid colloid, iodine is incorporated into tyrosine residues located on which large glycoprotein molecule?
(A) Thyroxine-binding globulin (TBG)
(B) Thyroglobulin (Tg)
(C) Transthyretin
(D) Albumin

2011

208. The coupling of one Monoiodotyrosine (MIT) and one Diiodotyrosine (DIT) specifically produces:
(A) Triiodothyronine (T_3)
(B) Tetraiodothyronine (T_4)
(C) Reverse Triiodothyronine
(D) L-Tyrosine molecule

2010

209. The primary secretory product of the healthy thyroid gland is T_4; however, the most biologically active thyroid hormone at the tissue level is:
(A) T_4
(B) rT_3
(C) MIT
(D) T_3

2006

210. The peripheral conversion of T_4 to T_3 is catalyzed by enzymes known as:
(A) Peroxidases
(B) Hydroxylases
(C) Transferases
(D) 5'-deiodinases

2011

211. Reverse T_3 (rT_3) is best described biochemically as:
(A) An inactive metabolite formed by inner ring deiodination of T_4
(B) A highly active form of thyroid hormone synthesized in the cold
(C) The primary precursor for T_4 synthesis
(D) A hormone specific to calcium regulation

2016

212. Thyroid hormones primarily increase the basal metabolic rate (BMR) by stimulating the synthesis of:
(A) Myosin heavy chains
(B) Glycogen synthase
(C) Na^+/K^+ ATPase pumps
(D) Acetylcholinesterase

2021

213. Active transport of iodide into the thyroid follicular cell is mediated by the Sodium-Iodide Symporter (NIS), which is primarily driven by:
(A) The Na^+/K^+ ATPase sodium concentration gradient
(B) ATP hydrolysis directly by the symporter
(C) A sustained outward directed potassium ion gradient
(D) Facilitated diffusion

2018

214. High levels of circulating T_3 and T_4 exert negative feedback primarily on:
(A) The posterior pituitary
(B) The adrenal cortex zones of the adrenal gland
(C) Parafollicular C-cells
(D) The anterior pituitary (thyrotrophs) and the hypothalamus

2008

215. A fundamental developmental role of thyroid hormones in neonatal mammals is to ensure the normal maturation of the:
(A) Gastrointestinal tract
(B) Central nervous system (CNS)
(C) Renal tubules
(D) Lymphatic system

2009

216. Goitrogens, found in plants such as cassava and brassicas, predominantly cause goiter by:
(A) Directly destroying thyroid follicular cells
(B) Mimicking TSH action on the receptor
(C) Inhibiting the uptake and organification of iodine
(D) Enhancing the rapid clearance of T_4 from the blood

2015

217. Endemic goiter in domestic animals geographically correlates most strongly with a dietary deficiency of:
(A) Iron
(B) Selenium
(C) Copper
(D) Iodine

2006

218. Hypothyroidism in adult dogs frequently presents with which classic constellation of clinical signs?
(A) Lethargy, weight gain, alopecia, and cold intolerance

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(B) II, III, I, V, IV
(C) III, V, II, I, IV
(D) II, V, I, III, IV

2006

241. Parturient paresis (milk fever) in dairy cows is fundamentally a metabolic disorder characterized by:
(A) Acute hypocalcemia due to massive calcium drain into milk
(B) Acute hypercalcemia at the onset of lactation
(C) Severe and progressive hypoglycemia occurring post-calving
(D) Magnesium deficiency in the diet

2023

242. Why does milk fever cause flaccid paralysis in cows rather than the tetany typically seen in hypocalcemic dogs?
(A) Because cows have intrinsically higher skeletal muscle mass
(B) Because ruminal fermentation produces inhibitory neurotoxins
(C) Because the threshold for action potentials increases
(D) Requirement of calcium for ACh release at neuromuscular junctions

2004

243. Nutritional secondary hyperparathyroidism in animals is most classically caused by a diet that is:
(A) Low in calcium and high in phosphorus
(B) High in calcium and low in phosphorus
(C) High in vitamin D and low in magnesium
(D) Low in protein and high in carbohydrates

2025

244. A diet consisting entirely of unsupplemented meat fed to domestic cats typically results in:
(A) Acute primary hypoparathyroidism
(B) Pathological hypervitaminosis A
(C) Vitamin C deficiency (Scurvy)
(D) Nutritional secondary hyperparathyroidism

2005

245. "Bran disease" (osteodystrophia fibrosa) in horses is a form of nutritional secondary hyperparathyroidism caused by excessive consumption of wheat bran, which contains high levels of:
(A) Insoluble oxalates
(B) Phytate and Phosphorus
(C) Dietary calcium
(D) Plant goitrogens

2006

246. Renal secondary hyperparathyroidism (renal osteodystrophy) occurs in chronic kidney disease primarily due to:
(A) Excessive loss of calcium in the urine
(B) Pathological overproduction of the hormone calcitonin
(C) Excessive dietary intake of Vitamin D
(D) Reduced 1,25-dihydroxycholecalciferol synthesis and phosphate retention

NODIA

2018

247. Eclampsia in lactating bitches and queens presents with muscle tremors, panting, and tetany. The biochemical cause is:
(A) Hypomagnesemia
(B) Hypocalcemia
(C) Hypoglycemia
(D) Hypokalemia

2015

248. The administration of anionic salts to pre-partum dairy cows helps prevent milk fever by:
(A) Inducing metabolic alkalosis, which directly stimulates bone resorption
(B) Blocking the specific intestinal absorption of dietary phosphorus
(C) Increasing the secretion of calcitonin
(D) Inducing mild metabolic acidosis to enhance tissue sensitivity to PTH

2024

249. Primary hyperparathyroidism, though rare, is typically caused by a functional parathyroid adenoma and results in:
(A) Hypercalcemia and hypophosphatemia
(B) Hypocalcemia and hyperphosphatemia
(C) Hypocalcemia and hypophosphatemia
(D) Hypercalcemia and hyperphosphatemia

2014

250. Match the mineral metabolism disorder in List I with its hallmark description or mechanism in List II:
List I: (Metabolism Disorder)
P. Milk Fever
Q. Renal Osteodystrophy
R. Bran Disease
S. Primary Hyperparathyroidism
List II: (Hallmark Description/Mechanism)
1. Rubber jaw in dogs with failing kidneys
2. Parathyroid adenoma causing hypercalcemia
3. High phosphorus diet in horses
4. Acute hypocalcemia at onset of lactation
(A) P-4, Q-1, R-3, S-2
(B) P-3, Q-1, R-4, S-2

(C) GnRH
(D) Prolactin

2014

296. In the two-cell, two-gonadotropin model of follicular estrogen synthesis, theca cells produce androgens which are then aromatized to estrogens in the:
(A) Oocytes
(B) Granulosa cells
(C) Stromal cells
(D) Luteal cells

2014

297. Relaxin, a peptide hormone secreted during late pregnancy, facilitates parturition primarily by:
(A) Stimulating massive uterine contractions
(B) Softening the cervix and relaxing pelvic ligaments
(C) Inducing pulmonary surfactant production in the fetus
(D) Triggering the reflex of mammary milk let-down

2022

298. The administration of Prostaglandin F_2-alpha (PGF_2a) is commonly used in veterinary medicine to synchronize estrus in cattle. Its primary mechanism of action is to:
(A) Stimulate a massive LH surge
(B) Induce rapid luteolysis of a mature corpus luteum
(C) Directly stimulate the growth of a dominant follicle
(D) Prevent ovulation

2008

299. During the luteal phase of the estrous cycle, high levels of progesterone exert a negative feedback effect to strictly prevent:
(A) Preovulatory surge of GnRH and LH
(B) The secretion of prolactin
(C) Endometrial glandular development
(D) Natural regression of the corpus luteum

2023

300. Which biochemical marker is routinely measured 21 to 24 days post-mating in dairy cattle to confirm the presence of a functional corpus luteum?
(A) Estradiol
(B) Progesterone
(C) Luteinizing Hormone
(D) Cortisol

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2015

261. The immunosuppressive and anti-inflammatory effects of pharmacological doses of glucocorticoids are mediated largely by inhibiting:
(A) Phospholipase A_2 and COX-2
(B) Membrane adenylate cyclase
(C) Receptor tyrosine kinases
(D) Nuclear DNA polymerases

2007

262. Which precursor molecule acts as the direct substrate for aldosterone synthase in the zona glomerulosa?
(A) Progesterone
(B) Cortisol
(C) DHEA
(D) Corticosterone

2008

263. Epinephrine stimulates hepatic glycogenolysis by binding to which receptor type, thereby elevating intracellular cAMP?
(A) Alpha-1 adrenergic receptor
(B) Beta-2 adrenergic receptor
(C) Alpha-2 adrenergic receptor
(D) Beta-1 adrenergic receptor

2021

264. In birds and rodents, the primary functional glucocorticoid secreted by the adrenal cortex is:
(A) Cortisol
(B) Cortisone
(C) Aldosterone
(D) Corticosterone

2023

265. Hyperadrenocorticism, commonly known as Cushing's syndrome, is most frequently observed in which domestic species?
(A) Cats
(B) Cattle
(C) Swine
(D) Dogs

2011

266. Pituitary-dependent hyperadrenocorticism (PDH) is characterized by a functional microadenoma that excessively secretes:
(A) CRH
(B) Cortisol
(C) ACTH
(D) Aldosterone

2006

267. A classical clinical sign of canine Cushing's syndrome includes pendulous abdomen (potbelly), which is fundamentally caused by:
(A) Hepatomegaly and muscle weakness/wasting
(B) Severe ascites and portal hypertension
(C) Extreme fluid retention due to sodium overload
(D) Splenomegaly

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2019

268. Typical blood profile abnormalities in an animal suffering from naturally occurring hyperadrenocorticism include:
(A) Persistent hypoglycemia and significant eosinophilia
(B) Severe hyponatremia and hyperkalemia
(C) Hypocalcemia and hypophosphatemia
(D) Hyperglycemia, hypercholesterolemia, and elevated ALP

2002

269. Hypoadrenocorticism (Addison's disease) involves the autoimmune destruction of the adrenal cortex, leading to a critical deficiency in:
(A) Deficiency in both mineralocorticoids and glucocorticoids
(B) Only mineralocorticoids
(C) Only glucocorticoids
(D) Deficiency in both epinephrine and norepinephrine

2012

270. The classic electrolyte imbalance associated with a severe Addisonian crisis (mineralocorticoid deficiency) is:
(A) Hypernatremia and Hypokalemia
(B) Hypercalcemia and Hypophosphatemia
(C) Hypomagnesemia and Hyperchloremia
(D) Hyponatremia and Hyperkalemia

2011

271. Iatrogenic hyperadrenocorticism is caused by:
(A) Chronic high-dose exogenous glucocorticoid administration
(B) Sudden and unplanned withdrawal of ongoing glucocorticoid therapy
(C) An adrenal tumor
(D) A hypothalamic defect

2018

272. If a dog with iatrogenic hyperadrenocorticism has glucocorticoid therapy abruptly stopped, the animal is at immediate risk of:
(A) Massive ACTH surge leading to acute pituitary apoplexy
(B) Acute hepatic necrosis
(C) Rapid tumor growth
(D) Iatrogenic Addisonian crisis due to severe adrenal atrophy

the functional L-gulonolactone oxidase enzyme, which catalyzes the final step in the biosynthetic pathway from glucose. Consequently, these species must obtain ascorbic acid through their diet to prevent scurvy and maintain normal health.

10. (A) P-3, Q-4, R-2, S-1
Beta-carotene serves as a precursor for retinol, while panthenol is converted into pantothenic acid. 7-Dehydrocholesterol is the cutaneous precursor that forms cholecalciferol upon exposure to ultraviolet light. Menadione is a synthetic form of vitamin K, specifically known as vitamin K_3. These relationships are fundamental to understanding how various chemical compounds contribute to the total vitamin activity in animals.

11. (B) Pyridoxal phosphate
Pyridoxal phosphate is the active coenzyme form of vitamin B_6, which is essential for numerous reactions in amino acid metabolism. It facilitates the transfer of amino groups in transamination reactions and the removal of carboxyl groups in decarboxylation reactions. This vitamin is vital for the synthesis of neurotransmitters and the conversion of various amino acids into important metabolic intermediates.

12. (B) It acts as a mobile carrier of CO_2 during enzymatic carboxylation reactions
Biotin functions as an essential coenzyme for several carboxylase enzymes by acting as a mobile carrier of carbon dioxide. This activity is critical for metabolic pathways such as gluconeogenesis, fatty acid synthesis, and amino acid metabolism. By facilitating the addition of carboxyl groups to various substrates, biotin enables the conversion of small molecules into essential intermediates for cellular energy.

13. (A) Cyanocobalamin
Cyanocobalamin, or vitamin B_{12}, possesses a complex chemical structure characterized by a corrin ring system. At the center of this ring is a cobalt ion, which is essential for the vitamin's biological activity. This unique structure allows it to function as a coenzyme in important reactions, such as the synthesis of DNA and the metabolism of fatty acids.

14. (C) The thiazole ring
Thiamine pyrophosphate is the active coenzyme form of thiamine, featuring a thiazole ring that provides its catalytic power. During the oxidative decarboxylation of alpha-keto acids, the thiazole ring acts as a nucleophile to stabilize intermediates. This chemical mechanism is essential for energy production in the citric acid cycle, particularly for the enzymes pyruvate dehydrogenase and alpha-ketoglutarate dehydrogenase.

15. (D) FMN and FAD
Riboflavin serves as the precursor for two essential coenzymes, flavin mononucleotide and flavin adenine dinucleotide. These molecules function as electron carriers in numerous oxidation-reduction reactions throughout the body. They are particularly important in the mitochondrial respiratory chain and the citric acid cycle, where they facilitate the transfer of energy from metabolic substrates to produce cellular ATP.

16. (C) An enediol functional group
The biological activity of vitamin C as a potent reducing agent is primarily due to the presence of its enediol functional group. This group allows the molecule to donate electrons easily, thereby neutralizing reactive oxygen species and protecting tissues from oxidative damage. Furthermore, this reducing capability is essential for the hydroxylation of collagen and the enhancement of intestinal iron absorption.

17. (B) One-carbon transfer reactions
Folate is essential for the transfer of one-carbon units, such as methyl and formyl groups, during metabolic processes. This function is critical for the synthesis of purines and thymidylate, which are required for DNA replication and cellular division. A deficiency in folate leads to impaired DNA synthesis, resulting in megaloblastic anemia and other significant developmental abnormalities in growing animals.

18. (D) Pyridoxine
The metabolic conversion of the amino acid tryptophan into niacin is a complex pathway that requires several B-vitamins as cofactors. Pyridoxine, in its active form of pyridoxal phosphate, is specifically required for the enzyme kynureninase in this pathway. Without sufficient vitamin B_6, the conversion of tryptophan to

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2003

284. Feline diabetes mellitus frequently presents with a strong component of insulin resistance combined with beta-cell dysfunction, making it most similar to:
(A) Type 1 Diabetes
(B) Maturity-Onset Diabetes of the Young (MODY)
(C) Cushing's disease
(D) Type 2 Diabetes

2015

285. A classic triad of clinical signs for an animal presenting with uncomplicated Diabetes Mellitus is:
(A) Polyuria, polydipsia, and polyphagia with weight loss
(B) Persistent oliguria, anorexia, and morbid obesity
(C) Diarrhea, vomiting, and abdominal pain
(D) Lethargy, alopecia, and hypothermia

2001

286. Untreated diabetes mellitus often progresses to Diabetic Ketoacidosis (DKA). Ketone bodies are synthesized in the liver directly from:
(A) Excess blood glucose
(B) Amino acids derived from extensive muscle tissue breakdown
(C) Acetyl-CoA derived from massive fatty acid oxidation
(D) Lactate

2021

287. Which of the following ketone bodies is chemically a volatile compound that imparts a fruity odor to the breath of an animal in severe DKA?
(A) Acetoacetate
(B) Beta-hydroxybutyrate
(C) Acetone
(D) Malonyl-CoA

2004

288. A common and rapid complication of diabetes mellitus in dogs is the formation of:
(A) Retinal detachment
(B) Bilateral cataracts
(C) Glaucoma
(D) Corneal ulcers

2023

289. The pineal gland acts as a neuroendocrine transducer by converting neural signals regarding the photoperiod into an endocrine output, which is:
(A) Serotonin
(B) Melatonin
(C) Dopamine
(D) Endorphin

2010

290. Melatonin secretion strictly exhibits a circadian rhythm characterized by:
(A) High levels during daylight and low levels during the night
(B) Constant levels regardless of light
(C) High levels during the night and low levels during the day
(D) High levels directly following food intake

2022

291. In seasonal breeding animals, melatonin regulates reproductive cyclicity by modifying the pulsatile release of which hypothalamic hormone?
(A) TRH
(B) CRH
(C) GnRH
(D) GHRH

2009

292. The principal testicular hormone, testosterone, is synthesized by Leydig cells under the direct control of:
(A) FSH
(B) Luteinizing Hormone (LH)
(C) ACTH
(D) Anterior pituitary Prolactin

2003

293. Which gonadal hormone is primarily responsible for the behavioral signs of estrus (heat) in female domestic animals?
(A) Progesterone
(B) Estrogen (Estradiol)
(C) Relaxin hormone
(D) Inhibin protein

2025

294. Progesterone is synthesized and secreted primarily by the:
(A) Ovarian follicle prior to ovulation
(B) Ovarian corpus luteum following ovulation
(C) Secretory uterine endometrium cells
(D) Anterior pituitary

NODIA

2013

295. Inhibin, produced by Sertoli cells in males and Granulosa cells in females, specifically functions to exert negative feedback strictly on the secretion of:
(A) LH
(B) FSH

(C) P-4, Q-2, R-1, S-3
(D) P-1, Q-4, R-3, S-2

2007

251. An iguana kept strictly indoors without UVB light exposure or dietary supplements develops swollen limbs and spontaneous fractures. This condition is known as:
(A) Visceral Gout
(B) Infectious osteomyelitis
(C) Skeletal osteopetrosis
(D) Metabolic Bone Disease

2007

252. The term "osteomalacia" specifically refers to:
(A) Failure of cartilage calcification at the epiphyseal plate in growing animals
(B) Increased bone mass due to decreased osteoclast activity
(C) Defective mineralization of newly formed osteoid matrix in adult animals
(D) Genetic defect in type I collagen synthesis

2017

253. The adrenal cortex is histologically and functionally divided into three zones. Which zone is responsible for the secretion of mineralocorticoids (aldosterone)?
(A) Zona fasciculata
(B) Zona reticularis
(C) Adrenal medulla
(D) Zona glomerulosa

2010

254. The primary physiological role of aldosterone is to target the renal distal tubule and collecting duct to:
(A) Increasing potassium reabsorption and systemic sodium excretion
(B) Decrease sodium and water reabsorption
(C) Reabsorb glucose
(D) Increasing sodium reabsorption and promoting potassium excretion

2009

255. The most potent natural glucocorticoid in mammals (e.g., dogs, pigs) is:
(A) Cortisol
(B) Corticosterone
(C) Aldosterone
(D) Deoxycorticosterone

2007

256. Glucocorticoids exert profound effects on intermediate metabolism. Their primary metabolic function during stress is to:
(A) Promote glycogen storage and suppress gluconeogenesis
(B) Inhibit lipolysis and promote protein synthesis
(C) Enhance peripheral glucose utilization by skeletal muscle
(D) Stimulate gluconeogenesis, lipolysis, and protein catabolism

2021

257. Which enzyme is uniquely present in the adrenal medulla, allowing for the conversion of norepinephrine to epinephrine?
(A) Rate-limiting tyrosine hydroxylase enzyme activity
(B) Phenylethanolamine N-methyltransferase (PNMT)
(C) DOPA decarboxylase
(D) Monoamine oxidase (MAO)

2018

258. The principal physiological trigger for the secretion of aldosterone via the Renin-Angiotensin-Aldosterone System (RAAS) is:
(A) Pathological state of hypernatremia
(B) High levels of ACTH
(C) Hypokalemia
(D) Hypovolemia or reduced renal perfusion

2016

259. Catecholamines from the adrenal medulla orchestrate the "fight-or-flight" response primarily by activating:
(A) Alpha and Beta adrenergic receptors
(B) Intracellular steroid receptors
(C) Muscarinic cholinergic receptors
(D) Nicotinic cholinergic receptors

2012

260. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cortisol is essential for survival during periods of prolonged starvation.
Reason (R): Cortisol acts permissively to enhance glucagon and epinephrine-induced gluconeogenesis, providing glucose for the brain.
(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is not the correct explanation of A
(C) A is true but R is false
(D) A is false but R is true

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ANSWERS

1. (B) Required in trace amounts to act specifically as a coenzyme or structural precursor
Essential vitamins are organic compounds that the host organism cannot synthesize in sufficient quantities for normal physiological function. These substances are required in minute amounts to serve as vital cofactors for enzymatic reactions or as precursors for important structural components. Their absence in the diet leads to specific deficiency diseases that impair metabolic health and systemic cellular functions.

2. (D) Lipid-soluble vitamins are generally stored in the body and pose a higher risk of toxicity
Lipid-soluble vitamins differ from water-soluble ones primarily in their storage capacity and excretion pathways. Because they are stored in adipose tissue and the liver, they can accumulate to dangerous levels, leading to hypervitaminosis. Conversely, water-soluble vitamins are typically excreted in the urine when intake exceeds the body's immediate needs, reducing the overall risk of toxicity from high intake.

3. (A) Tryptophan – Vitamin C
Tryptophan serves as a metabolic precursor for the synthesis of niacin, which is vitamin B_3, rather than vitamin C. While beta-carotene, ergosterol, and 7-dehydrocholesterol are correct provitamins for vitamins A, D_2, and D_3 respectively, vitamin C is not derived from tryptophan. Most animals synthesize vitamin C from glucose, except for those lacking the functional gulonolactone oxidase enzyme.

4. (C) Tryptophan
The amino acid tryptophan serves as a critical biochemical precursor for the endogenous production of niacin in various avian species. The efficiency of this conversion is a vital factor in poultry nutrition, as it influences the dietary niacin requirement. Providing adequate tryptophan ensures that these birds can maintain sufficient levels of the nicotinamide coenzymes required for vital energy metabolism.

5. (A) Vitamin D
Vitamin D is unique among vitamins because its active form, 1,25-dihydroxycholecalciferol, functions biochemically as a steroid hormone. It is derived from a cholesterol precursor and travels through the blood to distant target tissues. Upon reaching its destination, it binds to specific nuclear receptors to modulate the expression of genes involved in systemic calcium and phosphorus homeostasis in animals.

6. (D) Pantothenic acid
Pantothenic acid is a critical water-soluble vitamin that serves as the essential structural core for the synthesis of Coenzyme A. This coenzyme is vital for numerous metabolic processes, including the oxidation of fatty acids and the citric acid cycle. A deficiency in pantothenic acid directly limits the availability of Coenzyme A, thereby severely impairing cellular energy metabolism.

7. (B) Serve as an intracellular chain-breaking antioxidant
Alpha-tocopherol functions as the primary lipid-soluble antioxidant within cellular membranes, protecting them from oxidative damage. By acting as a chain-breaking antioxidant, it effectively neutralizes free radicals and prevents the peroxidation of polyunsaturated fatty acids. This mechanism is crucial for maintaining the structural integrity of cell membranes and preventing pathological conditions associated with high levels of cellular oxidative stress.

8. (C) Physicochemical classification
Vitamins are traditionally categorized using a physicochemical classification system based on their solubility in different solvents. This method divides them into water-soluble and lipid-soluble groups, which determines their absorption, transport, storage, and excretion characteristics. Water-soluble vitamins move easily through aqueous environments, while lipid-soluble vitamins require fats and bile salts for proper intestinal absorption and systemic transport through the blood.

9. (D) Mutation causing loss of functional L-gulonolactone oxidase
The inability of guinea pigs and primates to synthesize vitamin C is due to a specific genetic mutation. This mutation results in the loss of

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28. (A) Vitamin K
Vitamin K is an essential cofactor for the enzyme gamma-glutamyl carboxylase, which modifies specific glutamic acid residues on various proteins. This gamma-carboxylation process is critical for the activation of several blood-clotting factors, including prothrombin. Without functional vitamin K, these proteins cannot bind calcium or associate with membrane surfaces, leading to impaired coagulation and an increased risk of severe hemorrhage.

29. (A) Bile salts and dietary lipids
The absorption of lipid-soluble vitamins in the small intestine requires a mechanism similar to that of dietary fats. Bile salts are necessary to emulsify these vitamins into micelles, which then transport them to the intestinal mucosa for uptake. A deficiency in dietary lipids or impaired bile secretion can significantly reduce the bioavailability of these vitamins, leading to various deficiency syndromes.

30. (A) I and II
Retinal is a crucial component of the visual pigment rhodopsin, which is necessary for vision in low-light conditions. Additionally, retinoic acid acts as a signaling molecule that binds to nuclear receptors to regulate the transcription of genes involved in cellular growth and differentiation. However, retinol is primarily stored in the stellate cells of the liver rather than in skeletal muscle.

31. (D) Adipose tissue
Vitamin E is a lipid-soluble antioxidant that is primarily stored within the adipose tissue of the animal body. While the liver also contains significant amounts, the vast majority of the total body pool resides in fat deposits and cellular membranes. This distribution allows it to protect polyunsaturated fatty acids throughout the body from oxidative damage, particularly during periods of high metabolic activity.

32. (C) Variation in the attached isoprenoid side chain
The different forms of vitamin K, such as phylloquinone from plants and menaquinone from bacteria, share a common naphthoquinone ring structure. They are distinguished from each other by the specific length and degree of saturation of their attached isoprenoid side chains. These structural variations influence their absorption and metabolic distribution, although all forms ultimately function as cofactors for the gamma-carboxylation of proteins.

33. (B) Alpha-tocopherol
Vitamin E exists as several naturally occurring compounds, including four tocopherols and four tocotrienols. Among these, alpha-tocopherol is the most biologically active form and the most prevalent in animal tissues. Its superior activity is due to its high affinity for the tocopherol transfer protein in the liver, which ensures its preferential incorporation into plasma lipoproteins for transport to peripheral cells.

34. (D) Incorporation into chylomicrons for transport via the lymphatic system
Following intestinal absorption, vitamin E is incorporated into chylomicrons along with other dietary lipids. These particles enter the lymphatic system and are eventually released into the systemic circulation through the thoracic duct. This transport mechanism ensures that the lipid-soluble vitamin is properly shielded from the aqueous environment of the blood until it can be processed by the liver or peripheral tissues.

35. (A) Binds to nuclear receptors to modulate transcription of specific genes
Vitamin A, particularly in the form of retinoic acid, functions in a manner similar to steroid hormones by regulating gene expression. It enters the cell and binds to specific nuclear receptors, which then interact with hormone response elements on the DNA. This interaction modulates the transcription of target genes, influencing essential biological processes such as cellular differentiation, immune function, and embryonic development.

36. (C) Synthesis by ruminal microbiota
Ruminants generally do not require dietary vitamin K supplementation because the microbiota within the rumen synthesize large quantities of the vitamin. These microorganisms produce menaquinones during the fermentation process, which are subsequently absorbed by the host animal. This endogenous supply is typically sufficient to meet the animal's physiological requirements for blood coagulation and bone metabolism under normal grazing or feeding conditions.

NODIA

niacin is significantly impaired, potentially leading to signs of niacin deficiency.

19. (A) Coenzyme for pyruvate dehydrogenase complex
Vitamin C plays several vital roles in the body, including the hydroxylation of collagen fibers, the enhancement of iron absorption, and acting as a powerful antioxidant. However, it does not serve as a coenzyme for the pyruvate dehydrogenase complex. That specific metabolic function is performed by thiamine pyrophosphate, flavin adenine dinucleotide, nicotinamide adenine dinucleotide, lipoic acid, and coenzyme A.

20. (A) Both A and R are true and R is the correct explanation of A
Pantothenic acid is an essential component of the structure of Coenzyme A, which plays a pivotal role in the oxidation of fatty acids. Coenzyme A is necessary for the formation of acyl-CoA, the substrate for beta-oxidation. Therefore, a deficiency in pantothenic acid directly hinders the body's ability to utilize fats for energy, validating the essential relationship between this vitamin and lipid metabolism.

21. (A) 5'-deoxyadenosylcobalamin
5'-deoxyadenosylcobalamin is one of the active coenzyme forms of vitamin B_{12} required for the conversion of methylmalonyl-CoA to succinyl-CoA. This reaction is a critical step in the metabolism of odd-chain fatty acids and certain amino acids. Without this specific form of the vitamin, methylmalonic acid accumulates in the blood and urine, which can lead to metabolic acidosis and neurological impairment.

22. (D) Thiamine – Thiamine monophosphate
While riboflavin, niacin, and pyridoxine are correctly paired with their active coenzyme forms, the active form of thiamine is thiamine pyrophosphate rather than thiamine monophosphate. Thiamine pyrophosphate is essential for the oxidative decarboxylation of alpha-keto acids in energy metabolism. Thiamine monophosphate exists in the body but does not possess the catalytic activity required for these specific enzymatic reactions.

23. (B) A pteridine ring, p-aminobenzoic acid, and glutamic acid
Folic acid, also known as folate, has a unique chemical structure composed of three distinct subunits. It consists of a pteridine ring linked to para-aminobenzoic acid, which is further attached to one or more glutamic acid residues. This specific arrangement is essential for its function as a carrier of one-carbon units in the synthesis of nucleic acids and amino acids.

24. (C) Pyridoxal 5'-phosphate
Pyridoxal 5'-phosphate is the major vitamer of vitamin B_6 found in the systemic circulation. It is primarily transported bound to albumin, which protects it from degradation and ensures its delivery to peripheral tissues. Once it reaches the target cells, it serves as an essential coenzyme for a wide variety of metabolic processes, especially those involving the transformation of amino acids.

25. (D) Isoprene units
The core structural units of all lipid-soluble vitamins, including A, D, E, and K, are derived from the polymerization of isoprene units. These five-carbon building blocks are synthesized through the mevalonate pathway, which also produces cholesterol. This shared biosynthetic origin explains why lipid-soluble vitamins possess hydrophobic side chains, allowing them to dissolve in fats and integrate into biological membrane structures.

26. (A) Retinol-binding protein (RBP)
Retinol-binding protein is the specific transport protein responsible for mobilizing vitamin A from its primary storage site in the liver to peripheral tissues. To prevent renal excretion and maintain stability, the complex of retinol and its binding protein typically associates with transthyretin in the blood. This regulated transport system ensures that a constant supply of vitamin A is available for essential cellular processes.

27. (B) 1,25-dihydroxycholecalciferol
Cholecalciferol undergoes two successive hydroxylations to become biologically active. The first occurs in the liver to form 25-hydroxycholecalciferol, followed by a second hydroxylation in the kidney to produce 1,25-dihydroxycholecalciferol. This final form acts as a potent steroid hormone, regulating the intestinal absorption of calcium and phosphorus to maintain systemic mineral homeostasis and ensure the health of skeletal tissues.

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2023

273. The primary screening test used to differentiate between pituitary-dependent and adrenal-dependent hyperadrenocorticism is the:
(A) High-dose or low-dose dexamethasone suppression test
(B) ACTH stimulation test
(C) Standardized clinical water deprivation test
(D) Thyroid panel

2003

274. In a normal animal, the administration of a low dose of dexamethasone should logically result in:
(A) A significant increase in endogenous cortisol production
(B) A immediate rise in ACTH
(C) No change in cortisol levels
(D) Profound and sustained suppression of endogenous cortisol

2019

275. Animals with Cushing's disease frequently exhibit polyuria and polydipsia (PU/PD). This is primarily because excess cortisol:
(A) Directly destroys the glomerulus
(B) Stimulates extreme salt craving
(C) Causes diabetes insipidus by inhibiting ADH synthesis
(D) Antagonizes the action of ADH at the renal tubules

2013

276. Equine Pituitary Pars Intermedia Dysfunction (PPID), historically termed Equine Cushing's, presents classically with:
(A) Symmetrical bilateral alopecia
(B) Hirsutism (hypertrichosis), laminitis, and lethargy
(C) Acute hypokalemic collapse and muscular paralysis
(D) Severe vomiting and diarrhea

2014

277. The endocrine pancreas consists of the Islets of Langerhans. Which cell type is responsible for the secretion of Insulin?
(A) Alpha cells
(B) Beta cells
(C) Delta cells
(D) F (PP) cells

2007

278. Insulin is the primary anabolic hormone of the body. Its major metabolic effect on carbohydrate metabolism is to:
(A) Stimulating the process of hepatic gluconeogenesis in the liver
(B) Facilitating glucose entry into muscle and fat via $GLUT_4$ transporters
(C) Promote the breakdown of muscle glycogen
(D) Inhibit the pentose phosphate pathway

2023

279. Glucagon, secreted by alpha cells, acts principally on the liver to elevate blood glucose levels by stimulating:
(A) Intracellular glycolysis and glycogenesis
(B) Hepatic glycogenolysis and gluconeogenesis
(C) Lipogenesis and protein synthesis
(D) The conversion of glucose to fatty acids

2006

280. Somatostatin secreted by the pancreatic Delta cells strictly functions to:
(A) Stimulate both insulin and glucagon secretion
(B) Inhibiting the secretion of both insulin and glucagon
(C) Act as the primary stimulus for digestive enzyme release
(D) Enhancing intestinal motility and gaming emptying

2004

281. Insulin is synthesized as a single-chain precursor called proinsulin, which is cleaved into active insulin and:
(A) Connecting peptide (C-peptide)
(B) Polypeptide A chain
(C) Polypeptide B chain
(D) Pancreatic amylin

NODIA

2005

282. The mechanism of insulin secretion by pancreatic beta cells involves glucose entering the cell, leading to ATP production, which specifically closes:
(A) Voltage-gated calcium channels
(B) ATP-sensitive potassium channels
(C) Sodium-calcium exchangers
(D) Chloride channels

2010

283. Diabetes mellitus in dogs is most analogous to which condition in humans?
(A) Type 1 Diabetes (absolute insulin deficiency)
(B) Type 2 Diabetes (insulin resistance)
(C) Gestational Diabetes
(D) Diabetes Insipidus

37. (A) Riboflavin
Curled toe paralysis is a characteristic deficiency symptom observed in growing chicks lacking sufficient dietary riboflavin. This condition results from the degeneration of the sciatic nerves, leading to the inward curling of the toes and eventual inability to walk. Because riboflavin is essential for the flavoprotein enzymes involved in energy metabolism, its deficiency severely impacts the development of the nervous system.

38. (D) Vitamin B_1 (Thiamine)
Polyneuritis in poultry, often characterized by a distinctive stargazing posture, is caused by a severe deficiency of thiamine. This posture results from the retraction of the head due to neurological dysfunction and muscular weakness. Since thiamine is vital for glucose metabolism in the brain, its absence leads to energy depletion in nervous tissues, resulting in acute clinical signs of ataxia and paralysis.

39. (B) Vitamin E
Encephalomalacia, also known as crazy chick disease, is a neurological disorder in poultry caused by vitamin E deficiency. It is characterized by hemorrhages and edema in the cerebellum, leading to symptoms such as ataxia, tremors, and sudden death. This condition occurs because vitamin E is essential for protecting the brain's high concentration of polyunsaturated fatty acids from oxidative damage and lipid peroxidation.

40. (C) I, III and IV
Vitamin toxicities can cause severe health problems in animals. Excessive vitamin A leads to bone deformities and teratogenesis, while hypervitaminosis D results in pathological calcification of soft tissues like the heart and kidneys. High doses of synthetic vitamin K_3 can induce hemolytic anemia in certain species. Conversely, vitamin C toxicity is extremely rare in animals and does not typically cause hepatic necrosis.

41. (B) Pantothenic acid
Goose-stepping in swine is a unique neurological gait abnormality resulting from a deficiency of pantothenic acid. This condition is caused by the degeneration of peripheral nerves, particularly those in the hind limbs, which leads to a stiff-legged walk. Because pantothenic acid is essential for synthesizing coenzyme A, its deficiency disrupts energy metabolism and neurotransmitter production, impairing normal motor function and coordination.

42. (D) Niacin
Black tongue disease in dogs is the clinical manifestation of niacin deficiency and is equivalent to human pellagra. It is characterized by severe inflammation and ulceration of the oral mucosa, leading to a dark discoloration of the tongue. This condition occurs when the diet lacks sufficient niacin or its precursor, tryptophan, thereby impairing the production of essential nicotinamide adenine dinucleotide coenzymes.

43. (A) Dicumarol acting as a Vitamin K antagonist
Sweet clover disease is a hemorrhagic condition in cattle caused by the ingestion of moldy sweet clover hay containing dicumarol. Dicumarol acts as a potent antagonist of vitamin K by inhibiting the recycling of the vitamin needed for the activation of clotting factors. Consequently, the animal's blood fails to clot properly, leading to internal bleeding and potentially fatal hemorrhages following minor injuries.

44. (C) Selenium
Exudative diathesis is a severe deficiency syndrome in chicks caused by a concurrent lack of vitamin E and the trace mineral selenium. It is characterized by abnormal capillary permeability, leading to the accumulation of subcutaneous fluid and edema. Both nutrients work synergistically in the antioxidant defense system, and a deficiency in both severely compromises the integrity of blood vessels and cellular membranes.

45. (A) Cyanocobalamin
A deficiency in cyanocobalamin, or vitamin B_{12}, leads to megaloblastic anemia through the methyl trap hypothesis. In this mechanism, folate becomes trapped in its methylated form because the vitamin B_{12}-dependent enzyme methionine synthase is inactive. This prevents the regeneration of tetrahydrofolate, which is essential for DNA synthesis. The resulting impairment in erythropoiesis causes the production of large, immature, and dysfunctional red blood cells.

46. (D) Rickets
Rickets is the hallmark disease of vitamin D deficiency in young, rapidly growing animals.

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It is characterized by the failure of osteoid mineralization at the growth plates, leading to soft, deformed bones and enlarged joints. This condition occurs because vitamin D is essential for the intestinal absorption of calcium and phosphorus, which are necessary for the proper calcification of the developing skeleton.

47. (B) Petechial hemorrhages and poor wound healing
Scurvy-like symptoms occur in species that cannot synthesize vitamin C, such as primates and guinea pigs, when dietary intake is insufficient. The primary signs include petechial hemorrhages, swollen gums, and poor wound healing due to impaired collagen synthesis. Vitamin C is an essential cofactor for the hydroxylation of proline and lysine residues, which is necessary for the structural stability of collagen fibers.

48. (C) Squamous metaplasia and night blindness
Severe vitamin A deficiency in cattle leads to squamous metaplasia of epithelial tissues and night blindness. Squamous metaplasia results in the thickening and keratinization of mucous membranes, increasing susceptibility to infections. Night blindness occurs because vitamin A is a vital component of rhodopsin, the pigment in the retina responsible for vision in low light. These symptoms highlight the vitamin's role in tissue maintenance and vision.

49. (D) Biotin
Avidin is a protein found in raw egg whites that acts as a potent anti-vitamin by binding very tightly to biotin. This binding prevents the intestinal absorption of the vitamin, leading to a deficiency if large quantities of raw eggs are consumed. Heat denaturation during cooking inactivates avidin, which explains why cooked eggs do not pose a risk for inducing biotin deficiency in animals.

50. (B) I, II, III and IV
Several compounds act as vitamin antagonists by interfering with their metabolic pathways. Dicumarol inhibits vitamin K recycling, while methotrexate and isoniazid antagonize folic acid and vitamin B_6 respectively. Pyrithiamine blocks the activation of thiamine, causing neurological signs. However, amprolium is a thiamine antagonist used to treat coccidiosis, not an antagonist of vitamin C, making the fifth statement incorrect in the list.

51. (B) Dihydrofolate reductase
Methotrexate is a potent anti-vitamin that acts as a competitive inhibitor of the enzyme dihydrofolate reductase. This enzyme is essential for converting dihydrofolate into its active form, tetrahydrofolate, which is required for the synthesis of thymidylate and purines. By blocking this step, methotrexate effectively halts DNA synthesis and cellular replication, which is why it is used as a chemotherapy agent and an immunosuppressant.

52. (B) Thiaminase
Bracken fern poisoning in horses is caused by the presence of the enzyme thiaminase in the plant. When ingested, this enzyme destroys thiamine in the gastrointestinal tract, leading to a severe deficiency. Since thiamine is vital for energy metabolism in the central nervous system, its depletion results in acute neurological signs, such as ataxia, tremors, and a characteristic crouched stance known as bracken staggers.

53. (A) Warfarin
Warfarin is a widely used anticoagulant drug that acts as a competitive antagonist of vitamin K. It inhibits the enzyme vitamin K epoxide reductase, which is necessary for recycling the vitamin into its active form. Without active vitamin K, the gamma-carboxylation of clotting factors is impaired, preventing their activation and significantly increasing the time required for blood to clot during injury.

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54. (C) Thiamine
Amprolium is a structural analog of thiamine that is utilized as a coccidiostat in the poultry industry. It works by competitively inhibiting the uptake of thiamine by coccidial parasites, which have a much higher requirement for the vitamin than the host. By starving the parasites of thiamine, amprolium effectively controls the infection, although excessive doses can occasionally induce thiamine deficiency in the birds.

55. (D) Thiamine
Raw fish contains the enzyme thiaminase, which breaks down dietary thiamine in the gut of carnivores. Chronic consumption of raw fish can lead to Chastek paralysis, a severe neurological condition characterized by ataxia, seizures, and head retraction. This paralysis occurs because thiamine is essential for the oxidative

decarboxylation reactions necessary to provide energy to the brain and maintain normal nervous system function.

56. (C) Vitamin B_6
Isoniazid is a primary drug for treating tuberculosis that frequently causes peripheral neuropathy by interfering with vitamin B_6 metabolism. The drug binds to pyridoxal phosphate, the active form of the vitamin, and enhances its renal excretion. To prevent these neurological side effects, patients and animals receiving isoniazid are typically supplemented with vitamin B_6 to maintain adequate levels for neurotransmitter synthesis and amino acid metabolism.

57. (B) Para-aminobenzoic acid
Sulfonamides are antimicrobial agents that act as anti-vitamins by structurally mimicking para-aminobenzoic acid. Bacteria require this compound to synthesize folic acid, which is necessary for their growth and replication. Sulfonamides competitively inhibit the enzyme dihydropteroate synthase, thereby blocking the incorporation of para-aminobenzoic acid into the folate molecule. This disruption starves the bacteria of essential folate, inhibiting their proliferation.

58. (D) Folic acid
Aminopterin is a potent anti-vitamin that specifically interferes with the metabolism of folic acid. Like methotrexate, it acts as a competitive inhibitor of dihydrofolate reductase, the enzyme responsible for regenerating active tetrahydrofolate. By blocking this critical pathway, aminopterin prevents the synthesis of nucleic acids and inhibits cellular division, making it a powerful tool in biochemical research and a former treatment for certain cancers.

59. (A) Impaired glucose oxidation leading to brain energy depletion
In ruminants, the ingestion of thiaminase leads to the breakdown of thiamine, resulting in a severe deficiency that causes cerebrocortical necrosis. Thiamine pyrophosphate is a vital coenzyme for enzymes like pyruvate dehydrogenase, which are essential for glucose oxidation. When these enzymes fail, the brain suffers from a critical depletion of energy, leading to neuronal death, edema, and characteristic clinical neurological signs.

60. (B) II, V, I, III, IV
Clinical thiamine deficiency begins with the ingestion of active thiaminase, which proceeds to cleave dietary thiamine within the gastrointestinal tract. This process leads to the depletion of cellular thiamine pyrophosphate pools, which subsequently impairs the activity of alpha-ketoglutarate dehydrogenase. The failure of this enzyme disrupts the citric acid cycle, causing an accumulation of pyruvate and lactate and leading to brain energy failure.

61. (A) Their relative concentrations in the diet and the animal body
Minerals are formally classified into macro and micro categories based on their required levels in the diet and their concentrations within the animal's body. Macro minerals are needed in relatively large amounts, typically expressed as grams per kilogram of diet. In contrast, micro minerals, or trace elements, are required in much smaller quantities, often measured in milligrams per kilogram or parts per million.

62. (D) Magnesium
Magnesium is strictly categorized as a macro mineral in animal physiology because it is required in large amounts for various biological processes. It plays a vital role in skeletal development, nerve transmission, and as a cofactor for hundreds of enzymatic reactions involving ATP. In contrast, copper, zinc, and selenium are trace elements that are needed by the body in much smaller concentrations.

63. (B) Acid-base balance and osmotic regulation
Sodium, potassium, and chloride are essential electrolytes that collectively regulate the animal's acid-base balance and osmotic pressure. They are responsible for maintaining the volume of extracellular and intracellular fluids, ensuring proper hydration and cellular function. Furthermore, these minerals are critical for the generation of membrane potentials, which are necessary for nerve impulse conduction and the initiation of muscle contractions throughout the body.

64. (C) It serves as the central atom in the porphyrin ring of hemoglobin
Calcium is a foundational macro mineral that provides structural integrity to the skeleton and acts as a vital intracellular second messenger. It is also absolutely required for the initiation

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mineral is more resistant to acid dissolution than the standard hydroxyapatite, thereby enhancing the strength and durability of these tissues. While essential in trace amounts for dental health, excessive intake can lead to fluorosis, causing abnormal bone growth and tooth discoloration in livestock.

83. (A) Selenium
The enzyme glutathione peroxidase is a selenium-dependent metalloenzyme that plays a vital role in protecting cells from oxidative stress. It uses selenium to catalyze the reduction of hydrogen peroxide and lipid hydroperoxides into harmless water and alcohols. By neutralizing these reactive molecules, selenium helps maintain the integrity of cellular membranes and prevents oxidative damage to proteins and DNA throughout the animal body.

84. (C) Potentiating the action of insulin via chromodulin
Chromium is a trace element that plays a significant role in carbohydrate and lipid metabolism by potentiating the action of insulin. It is thought to function as part of a low-molecular-weight protein called chromodulin, which enhances the binding of insulin to its receptor. This interaction improves glucose uptake by tissues, helping to maintain stable blood sugar levels and optimize energy utilization in animals.

85. (A) Zinc
Parakeratosis in pigs is a classical skin condition caused by a deficiency of dietary zinc. It is characterized by thick, scaly, and hyperkeratinized lesions that primarily affect the limbs and abdomen. This disorder occurs because zinc is essential for cellular proliferation and the normal maturation of skin cells. High levels of dietary calcium can exacerbate this deficiency by interfering with the intestinal absorption of zinc.

86. (D) Copper
Swayback, also known as enzootic ataxia, is a neurological disorder in neonatal lambs resulting from a maternal deficiency of copper. It is characterized by the failure of proper myelin formation in the central nervous system, leading to incoordination and paralysis. Since copper is required for the enzymes involved in phospholipid synthesis and iron metabolism, its absence during fetal development causes irreversible damage.

87. (B) Rapid growth and low iron content in sow's milk
Piglet anemia occurs because newborn pigs have limited iron stores at birth and experience very rapid growth during their first weeks of life. Furthermore, sow's milk is naturally low in iron, providing insufficient amounts to meet the piglets' increasing needs. To prevent this condition, indoor-raised piglets must be given supplemental iron injections shortly after birth to support the production of hemoglobin.

88. (C) Cobalt
Enzootic marasmus, commonly known as Coast disease, is a wasting condition in sheep and cattle caused by a deficiency of cobalt. In cobalt-deficient soils, pastures lack enough of the mineral for ruminal microbes to synthesize vitamin B_{12}. The resulting B_{12} deficiency impairs energy metabolism and erythropoiesis, leading to severe emaciation, anemia, and eventual death if the animals are not supplemented with cobalt.

89. (D) Selenium and Vitamin E
White muscle disease is a degenerative muscle condition in calves and lambs caused by a dual deficiency of selenium and vitamin E. These two nutrients work synergistically to protect muscle cells from oxidative damage. Without them, muscle fibers undergo necrosis and calcification, giving them a characteristic white appearance. This leads to symptoms such as stiffness, lameness, and cardiac failure in severely affected animals.

90. (D) I, II and III
Trace element deficiencies lead to specific clinical syndromes in animals. Manganese deficiency causes perosis in poultry, characterized by slipped tendons and leg deformities. Iodine deficiency results in endemic goiter due to impaired thyroid hormone synthesis. Copper deficiency leads to achromotrichia, the loss of hair pigment, because copper is essential for the enzyme tyrosinase, which is required for the production of melanin.

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91. (B) Copper
Steely wool is a clinical sign of copper deficiency in sheep, characterized by the loss of the natural crimp and strength of the wool fibers. This occurs because copper is an essential cofactor for the enzymes responsible for creating disulfide cross-links between keratin molecules. Without these cross-links, the wool becomes straight,

motifs in many transcription factors. These motifs consist of a zinc ion coordinated to specific amino acid residues, allowing the protein to recognize and bind to unique DNA sequences. This interaction is essential for the regulation of gene expression, influencing cellular growth, development, and immune responses.

74. (D) Lysyl oxidase
Copper is an essential cofactor for the enzyme lysyl oxidase, which is responsible for the cross-linking of collagen and elastin fibers. This process is vital for maintaining the structural integrity and elasticity of connective tissues, blood vessels, and bone matrix. A deficiency in copper can lead to fragile bones and weakened blood vessel walls, increasing the risk of spontaneous fractures and hemorrhages.

75. (A) Selenocysteine
Selenium exerts its primary biochemical effects through its incorporation into the unique amino acid selenocysteine. This amino acid is specifically integrated into various selenoproteins, such as glutathione peroxidase, which protect cells from oxidative damage. Unlike other amino acids, selenocysteine is encoded by a special codon in the mRNA, highlighting its essential role in the systemic antioxidant defense mechanisms of animals.

76. (A) Xanthine oxidase
Molybdenum is an essential cofactor for the enzyme xanthine oxidase, which catalyzes the conversion of hypoxanthine and xanthine into uric acid. This pathway is a critical step in the catabolism of purines. Molybdenum is also required for other enzymes, such as sulfite oxidase and aldehyde oxidase, demonstrating its importance in several vital metabolic processes involving the detoxification of sulfur and nitrogen compounds.

77. (A) Mitochondrial Mn Superoxide dismutase
Manganese serves as an essential cofactor for the mitochondrial enzyme superoxide dismutase, which protects the cell from reactive oxygen species generated during energy production. This enzyme specifically neutralizes superoxide radicals within the mitochondria, preventing oxidative damage to vital cellular components. Through this mechanism, manganese plays a crucial role in maintaining mitochondrial health and ensuring the overall efficiency of cellular respiration and metabolism.

78. (C) Cytochrome P450 enzymes
Iron is a fundamental component of the heme group, which is central to the activity of cytochrome P450 enzymes. These enzymes are primarily located in the liver and are responsible for the detoxification of various drugs and endogenous compounds. Beyond its role in oxygen transport, iron's presence in these enzymes is vital for systemic metabolism and the maintenance of homeostasis in animals.

79. (D) Thyroid hormones (T_4 and T_3)
The only known physiological function of iodine in domestic animals is its incorporation into the thyroid hormones, thyroxine and triiodothyronine. These hormones are essential for regulating the basal metabolic rate, growth, and development. Iodine is actively taken up by the thyroid gland and attached to tyrosine residues, forming the building blocks of these critical endocrine signals that influence nearly every tissue.

80. (A) Both A and R are true and R is the correct explanation of A
Copper deficiency can induce anemia because copper is an essential component of ceruloplasmin, also known as ferroxidase I. This enzyme is required to oxidize ferrous iron into its ferric form, which is necessary for iron to bind to transferrin for transport in the blood. Without adequate copper, iron becomes trapped in tissues, making it unavailable for hemoglobin synthesis despite sufficient dietary intake.

81. (B) Manganese
Manganese acts as a critical trace element activator for the enzyme arginase, which is the final step in the urea cycle. This enzyme catalyzes the conversion of arginine into urea and ornithine, allowing the body to safely excrete excess nitrogen. Through this role, manganese is essential for protein metabolism and the prevention of ammonia toxicity, especially in animals consuming high-protein diets.

82. (D) Formation of acid-resistant fluoroapatite in bones and teeth
Fluorine exhibits its primary physiological effect by incorporating into the crystal structure of bones and teeth, forming fluoroapatite. This

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leading to parakeratosis, while excess iron can interfere with copper uptake. Additionally, zinc supplementation can help mitigate the toxic effects of cadmium by competing for binding sites. However, high phosphorus levels generally inhibit rather than enhance the absorption of magnesium, making the fourth statement incorrect in this context.

101. (A) Calcium, Phosphorus, and Zinc
Phytate is an organic compound found in plants that binds tightly to certain minerals, forming insoluble complexes that monogastric animals cannot digest. This significantly reduces the bioavailability of calcium, phosphorus, and zinc, potentially leading to deficiencies. Ruminants are less affected because their ruminal microbes produce phytase, an enzyme that breaks down phytate and releases the bound minerals for absorption by the host animal.

102. (D) Production of toxic hydrogen sulfide gas in the rumen
Excessive intake of sulfur in ruminants can lead to polioencephalomalacia through the production of hydrogen sulfide gas in the rumen. This toxic gas is inhaled or absorbed into the blood, where it interferes with cellular respiration in the brain. The resulting energy failure leads to cerebrocortical necrosis, characterized by neurological signs such as blindness, ataxia, and a distinctive stargazing posture in affected animals.

103. (B) Iron
Ascorbic acid, or vitamin C, significantly enhances the intestinal absorption of dietary iron by acting as a reducing agent. It maintains iron in the ferrous (Fe^{2+}) state, which is more soluble and easily taken up by the enterocytes than the ferric (Fe^{3+}) form. Furthermore, vitamin C can form soluble chelates with iron, preventing its precipitation and increasing its bioavailability for hemoglobin synthesis.

104. (C) Magnesium
High levels of potassium in spring forages can interfere with the absorption of magnesium in the rumen, leading to a condition called grass tetany. This metabolic disorder is characterized by acute hypomagnesemia, which causes muscle tremors, convulsions, and sudden death. Grazing ruminants are particularly susceptible when consuming lush, high-potassium pastures, requiring careful mineral management to ensure adequate magnesium levels are maintained during these periods.

105. (D) Normal bone mineralization and homeostasis
The physiological interaction between calcium, phosphorus, and vitamin D is essential for maintaining normal bone mineralization and systemic mineral homeostasis. Vitamin D regulates the intestinal absorption of both calcium and phosphorus, ensuring that sufficient levels are available for the formation of the hydroxyapatite matrix. Together with parathyroid hormone, these factors coordinate the continuous remodeling of bone and the regulation of extracellular mineral concentrations.

106. (C) Zinc
Zinc is a potent antagonist of copper absorption at the level of the intestinal enterocyte. High dietary zinc stimulates the production of metallothionein, a protein that binds copper with high affinity and traps it within the cell. When the enterocyte is sloughed off, the bound copper is lost in the feces. This interaction is often exploited to treat copper storage diseases in various animals.

107. (B) Glucosinolates and thiocyanates
Brassica forages, such as kale and cabbage, contain compounds like glucosinolates and thiocyanates that act as goitrogens. These substances interfere with the uptake of iodine by the thyroid gland and inhibit the activity of thyroid peroxidase. Chronic consumption of these plants can lead to the development of goiter in livestock, even if the diet contains otherwise sufficient levels of inorganic iodine.

108. (A) Manganese
Excess dietary calcium in growing poultry can precipitate a deficiency of manganese by forming insoluble complexes in the gastrointestinal tract. Manganese is essential for the development of bone and the maintenance of connective tissue integrity. A deficiency in this trace mineral leads to perosis, a condition where the gastrochondral tendon slips off its groove, causing crippling leg deformities and reduced growth rates.

109. (D) Food or food components providing health benefits and disease prevention
Nutraceuticals are defined as food or specific food components that provide physiological benefits

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limp, and lacks the structural integrity necessary for high-quality fleece.

92. (B) Mottled teeth, exostoses, and lameness
Chronic excessive ingestion of fluoride in cattle leads to a condition called fluorosis. This toxicity manifests as mottled, pitted teeth and the development of abnormal bony outgrowths known as exostoses. These changes result in severe lameness and pain, significantly reducing the animal's ability to graze and maintain productivity. Fluorosis typically occurs in areas with high natural fluoride levels in water or through industrial contamination.

93. (A) Selenium
Blind staggers and alkali disease are two classical syndromes associated with chronic selenium toxicity in livestock. Blind staggers is characterized by wandering, stumbling, and respiratory failure, while alkali disease involves lameness, hoof deformities, and hair loss. These conditions typically occur when animals graze on plants that accumulate high concentrations of selenium from the soil, leading to toxic levels in the body over time.

94. (C) Molybdenum
Teart is a condition in cattle characterized by severe scouring and diarrhea caused by the ingestion of toxic levels of molybdenum from certain pastures. High molybdenum intake interferes with copper metabolism, leading to a secondary copper deficiency that disrupts normal intestinal function. This condition can be managed by supplementing the affected animals with copper to counteract the antagonistic effects of the excess dietary molybdenum.

95. (D) Shortened long bones and poor feathering development
A severe deficiency of zinc in poultry leads to stunted growth, characterized by shortened long bones and poor feather development. Zinc is essential for the synthesis of collagen and the proliferation of chondrocytes in the growth plates. Furthermore, it is required for the normal maturation of skin and feathers. Consequently, inadequate zinc intake results in skeletal deformities and a ragged, unthrifty appearance in young birds.

96. (C) Copper
Copper toxicity is highly species-specific and is most common in sheep, which have a limited ability to excrete excess copper via the bile. When copper accumulates in the liver beyond its storage capacity, it is suddenly released into the blood, causing a massive hemolytic crisis. This results in severe jaundice, dark urine, and often rapid death, highlighting the importance of careful mineral balancing.

97. (B) Synergistic function in cellular antioxidant defense systems
Selenium and vitamin E work synergistically to protect cells from oxidative damage through different but complementary mechanisms. Vitamin E acts as a chain-breaking antioxidant within the lipid bilayer of membranes, while selenium is a component of glutathione peroxidase, which neutralizes peroxides in the aqueous cytoplasm. Together, they provide a comprehensive defense system that prevents lipid peroxidation and maintains the integrity of cellular structures.

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98. (D) Copper-Molybdenum-Sulfur axis
In ruminants, a critical three-way interaction between copper, molybdenum, and sulfur significantly limits the bioavailability of dietary copper. In the rumen, sulfur and molybdenum react to form thiomolybdates, which bind tightly to copper and prevent its absorption. This interaction can induce a secondary copper deficiency even when dietary copper levels are otherwise adequate, leading to symptoms like anemia and poor coat quality in cattle.

99. (A) Binding copper and inducing secondary copper deficiency
The formation of thiomolybdates in the rumen is the primary mechanism behind molybdenum-induced copper deficiency in ruminants. These compounds are formed from dietary molybdenum and sulfur and have a high affinity for copper. By binding to copper in the gastrointestinal tract and the blood, thiomolybdates make the mineral unavailable for essential biological processes, resulting in secondary deficiency symptoms despite sufficient total copper intake.

100. (B) I, II and III
Mineral-mineral interactions significantly affect the bioavailability of essential elements. High dietary calcium can inhibit zinc absorption,

and supporting cardiovascular health in certain companion animal and research models.

118. (C) Modulating the innate immune system via macrophage activation
Beta-glucans are unique complex carbohydrates used as nutraceuticals because they can modulate the innate immune system. They work by binding to specific receptors on the surface of macrophages and other immune cells, stimulating their activity and enhancing the animal's defense against pathogens. This immunomodulatory effect makes beta-glucans valuable for improving disease resistance and supporting overall immune health in livestock and pets.

119. (D) Liver
S-adenosylmethionine, commonly known as SAMe, is a naturally occurring compound that is frequently supplemented as a nutraceutical to support liver health in dogs and cats. It serves as a methyl donor in various biochemical reactions and is a precursor for the synthesis of glutathione, a major antioxidant. By increasing glutathione levels, SAMe helps protect hepatocytes from oxidative damage and supports detoxification processes.

120. (A) II, I, III, IV
The process of mitigating lipid peroxidation by antioxidant nutraceuticals follows a specific sequence. It begins when reactive oxygen species initiate a radical chain reaction in membrane lipids. The nutraceutical kemudian intercepts the lipid peroxyl radical, leading to the formation of a more stable nutraceutical radical. This final step terminates the oxidative chain reaction, thereby preventing further damage to the cellular membrane structure.

121. (B) Live microorganisms administered in adequate amounts to confer host health benefits
Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host animal. These beneficial bacteria or yeasts work by improving the balance of the intestinal microbiota, enhancing immune function, and protecting against pathogens. Common examples include species from the genera Lactobacillus and Bifidobacterium, which are widely used in animal nutrition to support digestive health and productivity.

122. (D) Non-digestible fiber that selectively stimulates beneficial gut bacteria
A prebiotic is a non-digestible food ingredient, typically a fiber, that selectively stimulates the growth or activity of beneficial bacteria in the gastrointestinal tract. Unlike probiotics, prebiotics are not live organisms but rather serve as fuel for the host's existing healthy microbes. By promoting the proliferation of beneficial bacteria like Bifidobacteria, prebiotics help maintain a healthy gut environment and improve overall systemic health.

123. (A) A mixture of live probiotics and complementary prebiotics
A synbiotic is a product that combines live probiotics with complementary prebiotics in a synergistic manner. The prebiotic component is specifically chosen to support the survival and growth of the probiotic strain within the host's gastrointestinal tract. This combination enhances the effectiveness of both components, leading to a more robust and beneficial impact on the gut microbiota and the animal's overall health.

124. (C) Lactobacillus and Bifidobacterium
The most common bacterial genera utilized as probiotics in animal nutrition are Lactobacillus and Bifidobacterium. These lactic acid-producing bacteria are naturally found in the gastrointestinal tract and are known for their ability to inhibit pathogens and support mucosal immunity. Their inclusion in animal diets helps maintain a balanced microbial population, which is essential for optimal digestion, nutrient absorption, and disease resistance.

125. (A) Occupying mucosal binding sites to prevent pathogenic bacterial adhesion
Competitive exclusion is a primary mechanism by which probiotics protect the host's gastrointestinal tract. The beneficial bacteria occupy specific binding sites on the intestinal mucosa, effectively blocking pathogenic bacteria from adhering and colonizing the gut. By physically competing for space and nutrients, probiotics reduce the population of harmful microbes, thereby preventing infections and maintaining the structural integrity of the intestinal barrier.

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beyond basic nutrition, including the prevention or treatment of diseases. In animal health, these substances are used to support joint function, enhance immunity, and improve overall wellness. Unlike pharmacological drugs, nutraceuticals are generally derived from natural sources and are integrated into the diet to promote long-term metabolic health.

110. (D) All of the statements are correct
Nutraceuticals encompass a wide range of compounds that promote health in animals. Phytochemicals and carotenoids act as potent antioxidants and pigments, while omega-3 fatty acids provide significant anti-inflammatory benefits. Glucosamine supports the health of articular cartilage, and polyphenols contribute to improved gastrointestinal function. Together, these diverse substances help modulate various physiological pathways to enhance the well-being and longevity of domestic animals.

111. (D) Precursors for less inflammatory Series 3 prostaglandins and resolvins
Omega-3 polyunsaturated fatty acids act as nutraceuticals by serving as precursors for the synthesis of series 3 prostaglandins and resolvins. These molecules are significantly less pro-inflammatory than the series 2 prostaglandins derived from omega-6 fatty acids. By incorporating omega-3s into cellular membranes, the overall inflammatory profile of the animal is lowered, which is beneficial for managing conditions such as osteoarthritis and skin allergies.

112. (B) Turmeric
Curcumin is a bioactive polyphenol extracted from the turmeric plant, known for its powerful anti-inflammatory and antioxidant properties. In animal nutrition, it is used as a nutraceutical to help manage chronic inflammation and support liver health. Its mechanism involves modulating several signaling pathways and inhibiting enzymes like cyclooxygenase-2, making it a popular natural alternative for promoting joint comfort and overall systemic health.

113. (C) Osteoarthritis
Chondroitin sulfate is a glycosaminoglycan that is frequently combined with glucosamine in veterinary nutraceuticals to manage osteoarthritis. It serves as a structural component of articular cartilage and helps maintain its elasticity and hydration by attracting water into the tissue. Together, these compounds support the repair of damaged cartilage and reduce inflammation within the joints, improving mobility and comfort in aging dogs and cats.

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114. (D) Act as free radical scavengers and modulate cell signaling
Plant polyphenols are valued as nutraceuticals primarily for their ability to act as potent free radical scavengers and modulators of cell signaling pathways. By neutralizing reactive oxygen species, they protect cells from oxidative stress and reduce the risk of chronic diseases. Furthermore, polyphenols can influence the expression of genes involved in inflammation and metabolism, providing a wide range of systemic health benefits.

115. (A) Garlic
Allicin is a sulfur-containing compound extracted from garlic that is renowned for its potent antimicrobial, antifungal, and antiviral properties. When garlic is crushed, the enzyme alliinase converts alliin into allicin, which can then inhibit the growth of various pathogens. In animal health, it is used as a natural supplement to support the immune system and promote a healthy gastrointestinal environment.

116. (B) Mitochondrial transport of long-chain fatty acids for beta-oxidation
L-carnitine is an essential nutraceutical that facilitates the transport of long-chain fatty acids across the inner mitochondrial membrane for beta-oxidation. This process is vital for the production of cellular energy from stored fats, particularly in tissues with high energy demands like heart and skeletal muscle. Supplementation with L-carnitine can enhance fat utilization, support weight management, and improve athletic performance in various animal species.

117. (A) Competitive inhibition of intestinal cholesterol absorption
Phytosterols are plant-derived compounds that are structurally similar to cholesterol. When added to animal diets, they competitively inhibit the absorption of dietary and biliary cholesterol in the small intestine. By displacing cholesterol from micelles, phytosterols effectively lower systemic cholesterol levels. This mechanism is primarily utilized in managing lipid profiles

of muscle contraction and the process of blood coagulation. However, calcium does not serve as the central atom in the hemoglobin molecule; that role is specifically performed by iron within the heme group.

65. (D) The formation of high-energy phosphate bonds in ATP
While the majority of phosphorus is stored in the skeleton, intracellular phosphorus is essential for cellular energy metabolism. It is a critical component of adenosine triphosphate, where it forms high-energy phosphate bonds that power nearly all biological processes. Additionally, phosphorus is a vital structural element of nucleic acids and phospholipids, which are necessary for DNA replication and the integrity of cellular membranes.

66. (C) Sulfur-containing amino acids such as methionine and cysteine
Sulfur is an essential element that animals primarily ingest in the form of sulfur-containing amino acids, such as methionine and cysteine. These amino acids are necessary for the synthesis of various proteins, enzymes, and other vital molecules like glutathione and taurine. While inorganic sulfur can be utilized by ruminal microbes to synthesize these amino acids, monogastric animals depend almost entirely on organic dietary sources.

67. (B) Magnesium
Magnesium is the central atom in the chlorophyll molecule, which is the primary pigment responsible for photosynthesis in plants. When animals consume forages, they ingest this magnesium, which then serves as a critical macro mineral for their own physiological needs. It is essential for bone health and acts as a cofactor for enzymes involved in energy production and the synthesis of DNA and proteins.

68. (A) Potassium
Potassium is the primary intracellular cation in animal cells and is responsible for maintaining the resting membrane potential. By working in conjunction with the sodium-potassium pump, it creates the electrochemical gradient necessary for nerve transmission and muscle function. Maintaining proper potassium levels is vital for cardiac health, as imbalances can lead to life-threatening arrhythmias and impaired muscular coordination across various physiological systems.

69. (D) Milligrams per kilogram (mg/kg) or parts per million (ppm)
Dietary requirements for micro minerals are typically expressed in milligrams per kilogram of the total diet, which is equivalent to parts per million. This unit reflect the very small quantities of these trace elements needed to support health and productivity. In contrast, macro minerals are measured in grams per kilogram or percentages, highlighting the significant difference in the magnitude of their requirement.

70. (A) P-4, Q-1, R-3, S-2
Iron is a central component of hemoglobin, which transports oxygen in the blood. Zinc is an essential cofactor for the enzyme carbonic anhydrase, involved in carbon dioxide transport. Copper is a vital part of ceruloplasmin, a protein necessary for iron metabolism. Selenium is incorporated into glutathione peroxidase, a key antioxidant enzyme. These mineral-protein associations are fundamental to maintaining normal physiological and metabolic health.

71. (D) Serving as an obligate cofactor for enzymes utilizing ATP
Magnesium plays a critical biochemical role by serving as an obligate cofactor for numerous enzymes that utilize or synthesize ATP. It stabilizes the structure of ATP molecules, allowing them to participate in phosphorylation reactions and energy-yielding processes. This makes magnesium essential for nearly every metabolic pathway, including glycolysis, the citric acid cycle, and the synthesis of vital proteins and nucleic acids.

72. (B) Cobalt
Cobalt is a trace element that is fundamentally required for the structural stability and biological activity of vitamin B_{12}. Ruminant animals depend on dietary cobalt for their ruminal microbes to synthesize this vitamin. Without adequate cobalt, the synthesis of vitamin B_{12} is impaired, leading to a deficiency that manifests as poor growth, anemia, and reduced reproductive performance in grazing livestock.

73. (C) Zinc fingers
Zinc plays a vital structural role in the formation of zinc fingers, which are common DNA-binding

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126. (D) Short-chain fatty acids (SCFAs) like acetate, propionate, and butyrate
Prebiotics such as fructo-oligosaccharides are fermented by beneficial bacteria in the hindgut to produce short-chain fatty acids. These molecules, including acetate, propionate, and butyrate, serve as important energy sources for the host and help lower the luminal pH. Furthermore, short-chain fatty acids play vital roles in regulating intestinal blood flow, stimulating water absorption, and modulating the immune system within the gut.

127. (B) Butyrate
Butyrate is a specific short-chain fatty acid produced during the fermentation of prebiotics that serves as the primary energy source for colonic epithelial cells. It is essential for maintaining the health and integrity of the intestinal mucosa by promoting cellular differentiation and inhibiting apoptosis in healthy cells. By supporting the colonic lining, butyrate enhances the gut barrier function and reduces local inflammation.

128. (C) By producing organic acids such as lactic acid
Probiotics lower the luminal pH of the gastrointestinal tract primarily by fermenting carbohydrates to produce organic acids, such as lactic acid and acetic acid. This acidic environment inhibits the growth of many pathogenic bacteria, which typically prefer a more neutral pH. By creating these conditions, probiotics effectively select for a beneficial microbial population and enhance the host's natural defenses against enteric infections.

129. (D) Bacteriocins
Probiotics can exert direct antimicrobial effects against pathogens by synthesizing and secreting specialized peptides known as bacteriocins. These molecules are toxic to specific rival bacterial species, often creating pores in their cell membranes or inhibiting their protein synthesis. Through the production of bacteriocins, probiotic strains can effectively reduce the population of harmful microbes in the gut, promoting a healthier microbial balance.

130. (A) P-4, Q-1, R-3, S-2
Probiotics include live spores like Bacillus subtilis, while prebiotics consist of non-digestible fibers such as mannan-oligosaccharides. Postbiotics are the soluble factors and metabolites secreted by bacteria that provide health benefits. Synbiotics are synergistic mixtures, such as Enterococcus faecium combined with inulin. Understanding these distinctions is crucial for the effective application of gut health products in veterinary medicine and animal production.

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131. (B) Salmonella species
In poultry production, competitive exclusion products are administered to day-old chicks to prevent the colonization of the gastrointestinal tract by Salmonella species. By establishing a healthy microbial population early in life, these products block the binding sites that pathogens would otherwise use to infect the birds. this strategy is essential for reducing the incidence of foodborne illnesses and improving overall flock health.

132. (B) Acting as decoy receptors for Type-1 fimbriae of pathogenic bacteria
Mannan-oligosaccharides function as prebiotics by acting as decoy receptors for the Type-1 fimbriae of pathogenic bacteria like Salmonella and E. coli. These pathogens bind to the MOS instead of the intestinal mucosa, allowing them to be flushed out of the system. This mechanism effectively reduces pathogenic colonization and supports gut health without the need for traditional antimicrobial drugs in animals.

133. (A) Peptides/Proteins, Steroids, and Amino acid derivatives
Hormones are broadly classified into three main groups based on their chemical structure: peptides and proteins, steroids, and amino acid derivatives. Peptides are made of amino acid chains, while steroids are derived from cholesterol. Amino acid derivatives, such as catecholamines, are synthesized from single amino acids like tyrosine. This classification determines how each hormone is synthesized, transported in the blood, and perceived by target cells.

134. (C) Aldosterone
Aldosterone is strictly a steroid hormone produced by the zona glomerulosa of the adrenal cortex. Like all steroids, it is derived from cholesterol and is highly lipophilic, allowing it to pass through cell membranes. In contrast, epinephrine and thyroxine are amino acid derivatives, while insulin is a peptide hormone. Aldosterone plays a critical role in regulating sodium and potassium balance in the body.

135. (D) Cholesterol
All naturally occurring steroid hormones are synthesized from cholesterol, which serves as the fundamental building block for these molecules. Cholesterol is converted into various steroids, including glucocorticoids, mineralocorticoids, and sex hormones, through a series of enzymatic reactions in the mitochondria and endoplasmic reticulum. This common origin explains the shared four-ring core structure that characterizes all steroid hormones in animals and humans.

136. (C) Tyrosine
Amine hormones, which include both catecholamines and thyroid hormones, are primarily derived from the amino acid tyrosine. Through specific enzymatic pathways, tyrosine is converted into dopamine, norepinephrine, and epinephrine, or it is iodinated to form thyroxine and triiodothyronine. This single amino acid is therefore essential for producing hormones that regulate the stress response, heart rate, and overall basal metabolic rate in animals.

137. (B) Arachidonic acid
Eicosanoids are a class of local signaling hormones, such as prostaglandins and leukantienes, that are synthesized from arachidonic acid. This twenty-carbon polyunsaturated fatty acid is released from membrane phospholipids by the enzyme phospholipase A_2. Once released, it is processed by various enzymes to produce signaling molecules that regulate inflammation, blood clotting, and smooth muscle contraction in nearly every tissue of the body.

138. (D) Ribosomal translation into a preprohormone via mRNA transcription
The biosynthesis of peptide hormones begins with the ribosomal translation of mRNA into a large precursor called a preprohormone. This molecule undergoes subsequent processing in the endoplasmic reticulum and Golgi apparatus, where it is cleaved into the active hormone and other peptide fragments. Finally, the mature hormone is stored in secretory vesicles until a signal triggers its release into the systemic circulation.

139. (A) Pregnenolone
The conversion of cholesterol to pregnenolone is the universal rate-limiting step in the biosynthesis of all steroid hormones. This reaction is catalyzed by the enzyme cholesterol side-chain cleavage enzyme, located on the inner mitochondrial membrane. The transport of cholesterol into the mitochondria, mediated by the StAR protein, regulated this initial step, which determines the overall rate of production for all steroid hormones.

140. (C) A is true but R is false
Peptide hormones are generally unable to cross the plasma membrane because they are hydrophilic, not lipophilic. Their polar nature prevents them from partitioning into the lipid bilayer of the cell. Instead, they must bind to specific receptors located on the cell surface to initiate their biological effects. The assertion that they cannot cross the membrane is true, but the reasoning provided is incorrect.

141. (A) 5-alpha-reductase
The enzyme 5-alpha-reductase is responsible for the conversion of testosterone into dihydrotestosterone, which is a significantly more potent androgen. This conversion occurs in specific target tissues, such as the prostate gland and skin, and is essential for the development of male secondary sexual characteristics. By increasing the androgenic signal, DHT plays a critical role in both normal physiology and certain pathological conditions.

142. (D) Aromatase
Aromatase is a critical enzyme that catalyzes the conversion of androgens, such as testosterone and androstenedione, into estrogens like estradiol and estrone. This reaction involves the aromatization of the A-ring of the steroid core and is the primary pathway for estrogen synthesis in both males and females. Aromatase activity is essential for reproductive function, bone health, and the regulation of various metabolic processes.

143. (B) Tryptophan
Melatonin is an amine hormone synthesized in the pineal gland that plays a central role in regulating circadian rhythms. Its primary biochemical precursor is the amino acid tryptophan, which is first converted into serotonin. Serotonin is then further modified through two enzymatic steps to produce melatonin. This synthesis is highly sensitive to light, with levels increasing during darkness to signal the nighttime phase.

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144. (B) Tyrosine → DOPA → Dopamine → Norepinephrine → Epinephrine
The biosynthesis of catecholamines follows a specific sequence beginning with the amino acid tyrosine. Tyrosine is first hydroxylated to form DOPA, which is then decarboxylated to produce dopamine. Dopamine is hydroxylated to norepinephrine, which can finally be methylated to form epinephrine. This pathway occurs in both the nervous system and the adrenal medulla, allowing for the rapid production of these signaling molecules.

145. (D) Membrane-bound and intracellular (cytosolic or nuclear) receptors
Hormone receptors are categorized based on their cellular location into membrane-bound and intracellular receptors. Peptide hormones and catecholamines typically bind to membrane-bound receptors because they cannot cross the lipid bilayer. In contrast, lipophilic hormones like steroids and thyroid hormones pass through the membrane to bind to cytosolic or nuclear receptors. This location determines the mechanism of signal transduction and the ultimate cellular response.

146. (C) Glucagon
Glucagon is a peptide hormone that is unable to pass through the cell membrane, so it must bind to a specific G-protein coupled receptor on the surface of target cells. Upon binding, it activates a second messenger system to elicit its metabolic effects, such as stimulating hepatic glycogenolysis. In contrast, cortisol, triiodothyronine, and progesterone are lipophilic and primarily bind to intracellular receptors.

147. (B) Spanning the plasma membrane seven times
G-protein coupled receptors are a major class of membrane receptors characterized by their unique structure, which spans the plasma membrane seven times. These receptors act as transducers that convert extracellular signals, like hormones or neurotransmitters, into intracellular responses. Upon ligand binding, the GPCR undergoes a conformational change that activates an associated G-protein, initiating a cascade of second messengers to alter cellular function.

148. (A) Receptor tyrosine kinases
The insulin receptor belongs to the family of receptor tyrosine kinases, which possess intrinsic enzymatic activity. When insulin binds to the extracellular domain, it triggers the autophosphorylation of tyrosine residues on the intracellular portion of the receptor. This activation creates binding sites for signaling proteins, initiating a cascade that leads to increased glucose uptake and the modulation of various metabolic and growth-related pathways.

149. (D) Ligand-activated transcription factors
Nuclear receptors are a class of intracellular proteins that function as ligand-activated transcription factors. Upon binding their specific lipophilic hormone, such as a steroid or thyroid hormone, the receptor undergoes a conformational change that allows it to bind to DNA. This interaction directly regulates the transcription of target genes, leading to changes in protein synthesis that alter the physiology and function of the cell.

150. (A) I and II
Intracellular receptors typically bind lipophilic hormones that can easily cross the plasma membrane. In their unliganded state, many steroid receptors are associated with heat shock proteins that maintain them in an inactive conformation. When the hormone binds, these proteins are released, allowing the receptor to dimerize and enter the nucleus. However, these receptors generally act slowly, taking minutes to hours to influence gene transcription.

151. (D) Hormone response element (HRE)
A hormone response element is a specific sequence of DNA within the promoter region of a gene that is recognized and bound by a hormone-receptor complex. This binding is a critical step for nuclear receptors to regulate the transcription of target genes. By interacting with these elements, the hormone-receptor complex can either stimulate or inhibit the production of specific proteins, thereby mediating the hormone's biological effects.

152. (B) JAK (Janus kinases)
Cytokine receptors, such as those for growth hormone and prolactin, lack intrinsic enzymatic activity. Instead, they recruit and activate intracellular kinases known as Janus kinases upon ligand binding. These kinases then phosphorylate the receptor and downstream signaling proteins, such as STATs, which translocate to the nucleus to regulate gene expression. This JAK-STAT

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vasoconstrictor through its action on V_1 receptors in the blood vessels. Additionally, it stimulates the kidneys to conserve water, helping to maintain blood volume. This dual action is vital for survival during periods of acute circulatory shock and trauma.

204. (C) Oxytocin
During the Ferguson reflex, the mechanical dilation of the cervix and vagina triggers sensory nerves that signal the hypothalamus to release large amounts of oxytocin. The resulting surge in hormone levels further stimulates uterine contractions, creating a positive feedback loop that facilitates the progress of parturition. This coordinated physiological response ensures that the uterus generates enough force to successfully deliver the fetus and complete the birth process in animals.

205. (D) Extracellularly, within the colloid of the thyroid follicle
The biosynthesis of thyroid hormones is unique because the critical steps, including the iodination of tyrosine and the coupling of iodotyrosines, occur extracellularly within the thyroid colloid. This protein-rich fluid is contained within the lumen of the thyroid follicles. By storing the hormones in this extracellular space bound to thyroglobulin, the thyroid gland can maintain a large reserve of thyroid hormone to ensure a steady supply for the body.

206. (C) Thyroid peroxidase (TPO)
Thyroid peroxidase is the essential enzyme responsible for multiple steps in the synthesis of thyroid hormones. It catalyzes the oxidation of iodide to iodine, the iodination of tyrosine residues on thyroglobulin, and the coupling of these residues to form T_3 and T_4. Located on the apical membrane of the follicular cells, TPO is the primary target for many anti-thyroid drugs used to treat hyperthyroidism in various species.

207. (B) Thyroglobulin (Tg)
Thyroglobulin is a large glycoprotein synthesized by the thyroid follicular cells and secreted into the follicular lumen. It acts as the scaffold upon which thyroid hormones are synthesized and stored. Each thyroglobulin molecule contains numerous tyrosine residues that can be iodinated and coupled to form thyroxine and triiodothyronine. The hormone remains bound to this protein until it is taken back up by the follicular cells for release into the blood.

208. (A) Triiodothyronine (T_3)
Triiodothyronine is produced in the thyroid gland by the coupling of one monoiodotyrosine residue and one diiodotyrosine residue. This reaction occurs on the thyroglobulin molecule within the follicular colloid. While the thyroid gland secretes some T_3, the majority of the body's triiodothyronine is generated in peripheral tissues through the deiodination of thyroxine. T_3 is the most biologically active form of thyroid hormone, exerting powerful effects on systemic metabolism and cellular function.

209. (D) T_3
While thyroxine is the primary hormone secreted by the thyroid gland, triiodothyronine is the most biologically active form at the tissue level. T_3 has a much higher affinity for the thyroid hormone receptor than T_4, allowing it to more effectively regulate gene expression. Most peripheral tissues convert T_4 into T_3 to elicit the desired metabolic response, making T_4 act essentially as a prohormone for the more potent triiodothyronine molecule.

210. (D) 5'-deiodinases
The peripheral conversion of thyroxine to the more active triiodothyronine is catalyzed by enzymes known as 5'-deiodinases. These enzymes remove one iodine atom from the outer ring of the T_4 molecule. This conversion is a critical step in the regulation of thyroid hormone activity, as it allows individual tissues to adjust their metabolic rate in response to systemic needs or localized environmental conditions, such as cold or illness.

211. (A) An inactive metabolite formed by inner ring deiodination of T_4
Reverse T_3 is an inactive metabolite of thyroxine that is formed when an iodine atom is removed from the inner ring of the T_4 molecule. This process is catalyzed by a different set of deiodinase enzymes than those that produce active T_3. The production of rT_3 is often increased during periods of severe illness, starvation, or stress, serving as a mechanism to conserve energy by reducing the systemic metabolic rate.

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peptide. When ANP binds to its receptor, it activates the intrinsic guanylate cyclase activity of the receptor, leading to the production of cGMP. This molecule then activates protein kinase G and other targets, which mediate the physiological effects of the hormone, such as vasodilation and increased renal sodium excretion to regulate blood pressure.

162. (B) Calmodulin
Intracellular calcium ions function as vital second messengers, often by binding to the regulatory protein calmodulin. This binding causes a conformational change in calmodulin, allowing it to interact with and activate various target enzymes, such as calmodulin-dependent kinases. Through this mechanism, calcium can regulate a wide range of cellular processes, including muscle contraction, neurotransmitter release, and the activity of several metabolic enzymes throughout the animal body.

163. (A) Hydrolysis to 5'-AMP by phosphodiesterase
The signaling action of cyclic AMP is terminated through its hydrolysis by the enzyme phosphodiesterase. This enzyme breaks the phosphodiester bond in cAMP, converting it into inactive 5'-adenosine monophosphate. By rapidly degrading the second messenger, the cell can tightly control the duration and intensity of the hormonal signal. Pharmacological inhibition of phosphodiesterase can prolong the effects of hormones that utilize the cAMP signaling pathway.

164. (C) Activation of adenylate cyclase
The activation of a stimulatory G-protein subunit by a hormone-receptor complex specifically leads to the activation of adenylate cyclase. This enzyme then produces cyclic AMP from ATP, initiating an intracellular signaling cascade. This pathway is utilized by many hormones, such as glucagon and epinephrine, to rapidly alter cellular metabolism and function. The resulting increase in cAMP levels is a critical step in transmitting the hormonal message.

165. (D) Ras-MAPK (Mitogen-Activated Protein Kinase) pathway
The Ras-MAPK pathway is a major kinase cascade frequently initiated by the activation of receptor tyrosine kinases. When a ligand like insulin or a growth factor binds, it triggers a sequence of phosphorylation events that activate Ras, Raf, and ultimately MAP kinases. These kinases then translocate to the nucleus to regulate the expression of genes involved in cell division, growth, and differentiation, mediating the long-term effects of these hormones.

166. (C) Gs protein alpha subunit
Cholera toxin causes severe dehydration by persistently activating the Gs protein alpha subunit in intestinal epithelial cells. The toxin prevents the GTPase activity of the Gs subunit, keeping it in a permanent "on" state. This leads to continuous activation of adenylate cyclase and excessively high levels of cyclic AMP. The resulting overstimulation of chloride channels causes a massive outflow of water and electrolytes into the intestinal lumen.

167. (B) It activates Protein Kinase C (PKC) in the presence of calcium
Diacylglycerol is a key second messenger produced by the cleavage of membrane phospholipids. It remains within the plasma membrane where it functions to activate protein kinase C. This activation requires the presence of both DAG and elevated levels of intracellular calcium. Once activated, PKC phosphorylates various target proteins, influencing a wide range of cellular processes, including cell growth, membrane transport, and the regulation of other signaling pathways.

168. (D) cGMP
In the process of phototransduction, light absorption by rhodopsin leads to the activation of phosphodiesterase, which rapidly degrades cyclic GMP. The resulting decrease in cGMP levels causes the closure of cGMP-gated sodium channels in the plasma membrane of rod cells. This leads to the hyperpolarization of the cell, which is the electrical signal that the brain interprets as light, allowing for vision in low-light environments.

169. (A) The hypophyseal portal vascular system
The hypothalamus controls the secretion of hormones from the anterior pituitary through the hypophyseal portal vascular system. Releasing and inhibiting hormones are secreted by hypothalamic neurons into a primary capillary plexus and then carried directly to the anterior pituitary via portal veins. This specialized blood supply allows small quantities of hypothalamic hormones to reach their target cells in the

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pituitary at high concentrations to regulate their activity.

170. (A) I, II, III and V
The hypothalamus synthesizes several critical releasing and inhibiting hormones, including TRH, CRH, GHRH, and GnRH, which regulate the anterior pituitary. These neurohormones are essential for coordinating the endocrine response to various physiological needs. However, luteinizing hormone is not produced by the hypothalamus; it is a gonadotropin synthesized and secreted by the anterior pituitary in response to hypothalamic stimulation, making the fourth item in the list incorrect.

171. (A) Dopamine
Dopamine is a unique hypothalamic hormone because its primary role is to chronically inhibit the secretion of prolactin from the anterior pituitary. Unlike most other hypothalamic factors that stimulate hormone release, dopamine acts as a prolactin-inhibiting factor. Any disruption in the connection between the hypothalamus and the pituitary typically leads to a dramatic increase in prolactin levels because the tonic inhibitory effect of dopamine is lost.

172. (D) Growth Hormone and TSH
Somatostatin is a hypothalamic hormone that functions as a potent inhibitor of growth hormone secretion from the anterior pituitary. In addition to its effect on GH, it also inhibits the release of thyroid-stimulating hormone. Somatostatin is produced in several other tissues, including the pancreas and gastrointestinal tract, where it also serves to inhibit the secretion of various hormones and enzymes to maintain metabolic balance in animals.

173. (B) Corticotroph cells of the anterior pituitary
The primary target for corticotropin-releasing hormone is the corticotroph cells located in the anterior pituitary. When CRH binds to its receptors on these cells, it stimulates the synthesis and release of adrenocorticotropic hormone. This process is the first step in the activation of the hypothalamic-pituitary-adrenal axis, which is essential for coordinating the body's response to stress and maintaining metabolic homeostasis through the production of glucocorticoids.

174. (C) Cortisol
Cortisol is the primary hormone involved in the negative feedback regulation of the hypothalamic-pituitary-adrenal axis. When systemic cortisol levels rise, the hormone acts on both the hypothalamus and the anterior pituitary to inhibit the further release of CRH and ACTH. This regulatory loop ensures that glucocorticoid levels are maintained within a narrow physiological range, preventing the harmful effects of chronic overexposure to these powerful stress hormones.

175. (D) GnRH
The pulsatile secretion of gonadotropin-releasing hormone is absolutely essential for its normal physiological efficacy. These intermittent pulses of GnRH stimulate the anterior pituitary to release FSH and LH, which are required for reproductive function. Conversely, continuous exposure to GnRH or its long-acting analogs leads to the downregulation of receptors on the pituitary cells, which actually inhibits the secretion of gonadotropins and halts reproductive activity.

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176. (C) Oxytocin and ADH
Oxytocin and antidiuretic hormone are neurohormones that are synthesized in the paraventricular and supraoptic nuclei of the hypothalamus. They are then transported down the axons of the hypothalamic-hypophyseal tract to the posterior pituitary, where they are stored in terminal vesicles. Upon appropriate physiological stimulation, these hormones are released directly into the systemic circulation to exert their effects on water balance and reproductive processes.

177. (B) Prolactin
If the pituitary stalk is severed, the secretion of most anterior pituitary hormones decreases because they lose their hypothalamic stimulatory input. However, prolactin secretion increases dramatically because it is normally under the tonic inhibitory control of hypothalamic dopamine. Without this inhibition, the lactotrophs in the anterior pituitary spontaneously secrete large amounts of prolactin, leading to hyperprolactinemia, which can cause abnormal milk production and reproductive dysfunction.

178. (A) Prolactin
Thyrotropin-releasing hormone is the primary stimulator for the release of TSH from the anterior pituitary. In addition to this role, TRH also acts as a potent stimulator for the secretion of prolactin. This dual function explains why conditions that cause elevated TRH, such as primary hypothyroidism, are often accompanied by increased prolactin levels, which can lead to galactorrhea or reproductive issues in affected animals.

179. (D) Hypothalamic hormone inhibiting its own synthesis and secretion
The ultra-short loop feedback mechanism occurs when a hypothalamic hormone directly inhibits its own synthesis and secretion. This is a local regulatory process that allows for precise control of hormone levels within the hypothalamus. This mechanism works in conjunction with longer feedback loops involving pituitary and target gland hormones to ensure that the entire endocrine axis remains properly balanced and responsive to the body's physiological needs.

180. (B) TRH release → Anterior pituitary → TSH release → Thyroid gland → T_3/T_4
The HPT axis follows a specific functional sequence to regulate metabolic activity. It begins with the release of thyrotropin-releasing hormone from the hypothalamus, which then stimulates the anterior pituitary to secrete thyroid-stimulating hormone. TSH travels through the blood to the thyroid gland, where it triggers the production and release of thyroxine and triiodothyronine, which then exert systemic metabolic effects.

181. (D) Insulin-like Growth Factor-1 (IGF-1)
Growth hormone exerts many of its growth-promoting effects indirectly by stimulating the liver and other tissues to produce insulin-like growth factor-1. IGF-1 travels through the blood to target organs, where it promotes cellular proliferation and skeletal growth. This indirect mechanism allows growth hormone to have a sustained and widespread impact on the development of tissues, particularly during the growth phase of young animals.

182. (B) Enhanced lipolysis in adipose tissue
In adult animals, growth hormone has significant direct metabolic effects, including the stimulation of lipolysis in adipose tissue. By breaking down stored fats into free fatty acids, GH provides an alternative energy source for tissues, which helps to conserve glucose and protein. This "glucose-sparing" effect is vital during periods of fasting or stress, allowing the body to maintain essential energy levels for the brain and other vital organs.

183. (C) An identical alpha subunit
The glycoprotein hormones of the anterior pituitary, including TSH, FSH, and LH, share a common structural feature: an identical alpha subunit. Their biological specificity is determined by their unique beta subunits, which allow each hormone to recognize and bind to its specific receptor. This shared structure is also seen in human chorionic gonadotropin, demonstrating a conserved evolutionary mechanism for creating a diverse family of signaling molecules from common subunits.

184. (D) Glucocorticoids such as cortisol and corticosterone
The primary physiological role of adrenocorticotropic hormone is to stimulate the cells of the adrenal cortex, specifically in the zona fasciculata and zona reticularis. In response to ACTH, these cells synthesize and secrete glucocorticoids like cortisol and corticosterone. These hormones are essential for the body's response to stress, as they regulate metabolic processes, immune function, and the maintenance of blood pressure across various animal species.

185. (A) Leydig cells
In males, luteinizing hormone specifically targets the Leydig cells located in the interstitial tissue of the testes. LH binding stimulates these cells to synthesize and secrete testosterone, the primary male sex hormone. Testosterone is essential for the development of male reproductive organs, the maintenance of secondary sexual characteristics, and the process of spermatogenesis, highlighting the central role of LH in male reproductive physiology and health.

186. (B) Development and maturation of ovarian follicles
Follicle-stimulating hormone plays a critical role in the female reproductive cycle by stimulating the growth and maturation of ovarian follicles. FSH also triggers the granulosa cells of the follicles to produce estrogens, which are necessary for the development of the uterine lining and the expression of estrus behavior. The proper

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pathway is essential for mediating the effects of various cytokines and growth factors.

153. (C) Dimerization and nuclear translocation
When a lipophilic ligand binds to its intracellular steroid receptor, it induces a conformational change that typically leads to the dimerization of two receptor molecules. This dimerized complex then translocates from the cytosol into the nucleus, where it can interact with specific DNA sequences. Once inside the nucleus, the complex acts as a transcription factor, regulating the expression of target genes that mediate the hormone's physiological actions.

154. (D) Nuclear residence even in unliganded states, often acting as repressors
Thyroid hormone receptors are unique because they reside in the nucleus even when they are not bound to their ligand. In the absence of thyroid hormone, these receptors often bind to DNA and act as transcriptional repressors by recruiting co-repressor proteins. When triiodothyronine binds, the receptor undergoes a conformational change that allows it to recruit co-activators instead, thereby initiating the transcription of target genes.

155. (A) Ion channel receptor – Intracellular GTP-binding domain
The pairing of ion channel receptors with intracellular GTP-binding domains is incorrect because these domains are characteristic of G-protein coupled receptors. Ion channel receptors are specialized proteins that form a pore across the membrane, allowing ions to pass through in response to ligand binding. The other options correctly describe the structural features of GPCRs, receptor tyrosine kinases, and steroid receptors, which use zinc fingers for DNA binding.

156. (B) DNA-binding domain (DBD)
The DNA-binding domain of a nuclear receptor is responsible for recognizing and binding to specific hormone response elements on the DNA. This domain typically contains zinc finger motifs that ensure high-affinity and sequence-specific interaction. By determining which genes are targeted, the DNA-binding domain ensures that the hormone-receptor complex regulates the correct set of physiological processes within the cell, such as growth or metabolism.

157. (A) Adenylate cyclase
Adenylate cyclase is a membrane-bound enzyme that catalyzes the conversion of ATP into cyclic AMP, a key second messenger. It is activated by the stimulatory G-protein subunit (Gs) in response to various hormones, such as glucagon or epinephrine. The resulting increase in cAMP levels initiates an intracellular signaling cascade, primarily through the activation of protein kinase A, which leads to changes in cellular activity and metabolism.

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158. (C) Protein Kinase A (PKA)
The principal intracellular target of cyclic AMP is protein kinase A, an enzyme that phosphorylates specific proteins to alter their function. cAMP binds to the regulatory subunits of PKA, causing the release of active catalytic subunits. These subunits then phosphorylate various enzymes and transcription factors, mediating the cellular response to hormones that use the cAMP signaling pathway. This phosphorylation cascade is vital for regulating energy metabolism and gene expression.

159. (D) Phosphatidylinositol 4,5-bisphosphate (PIP2)
In the IP3/DAG signaling pathway, the enzyme phospholipase C cleaves the membrane phospholipid phosphatidylinositol 4,5-bisphosphate. This reaction produces two distinct second messengers: inositol trisphosphate and diacylglycerol. While IP3 is water-soluble and diffuses into the cytosol to release calcium, DAG remains within the plasma membrane to activate protein kinase C. This dual-signal mechanism allows hormones to regulate a wide range of cellular functions simultaneously.

160. (B) I, II and III
In the IP3/DAG signaling cascade, inositol trisphosphate is a water-soluble molecule that diffuses through the cytosol to trigger the release of calcium from the endoplasmic reticulum. Meanwhile, diacylglycerol remains within the plasma membrane where it acts as a second messenger. Together with calcium, DAG activates protein kinase C to initiate further signaling. However, DAG stimulates rather than inhibits PKC, making the fourth statement incorrect.

161. (B) Atrial Natriuretic Peptide
Cyclic GMP acts as a second messenger primarily in response to hormones like atrial natriuretic

195. (D) Inserting aquaporin-2 channels into collecting duct apical membranes
Antidiuretic hormone increases water reabsorption in the kidney by stimulating the insertion of aquaporin-2 water channels into the apical membranes of the collecting duct cells. This process dramatically increases the permeability of the ducts to water, allowing it to be reabsorbed back into the systemic circulation. Without the action of ADH, these channels remain within the cell, and the kidney produces a large volume of very dilute urine.

196. (C) Uterine contraction during parturition and milk let-down
Oxytocin is essential for two major reproductive processes in mammals: uterine contraction during parturition and the milk let-down reflex. During birth, oxytocin stimulates the strong, rhythmic contractions of the uterine smooth muscle required to expel the fetus. During nursing, it causes the contraction of myoepithelial cells in the mammary gland, forcing milk into the ducts for ejection. These roles are critical for successful reproduction and neonatal care.

197. (B) Myoepithelial cells
Oxytocin initiates the milk let-down reflex by specifically targeting the myoepithelial cells that surround the milk-secreting alveoli in the mammary gland. When these cells contract in response to the hormone, they squeeze the milk out of the alveoli and into the duct system, making it available for the nursing offspring. This neuroendocrine reflex is triggered by stimuli such as suckling or the sight and sound of the neonate.

198. (D) Absolute deficiency in ADH hormone synthesis or release
Central diabetes insipidus is a disorder characterized by the absolute deficiency of antidiuretic hormone due to a defect in its synthesis or release from the hypothalamic-pituitary system. Animals with this condition cannot concentrate their urine, leading to the production of large volumes of dilute urine and a compensatory increase in water intake. This condition can be managed by administering synthetic analogs of ADH to restore normal renal water reabsorption.

199. (A) Nonapeptides
Both oxytocin and vasopressin are nonapeptides, meaning they are each composed of a chain of nine amino acids. They share a very similar structure, differing by only two amino acids, yet they exert vastly different physiological effects. This structural similarity is a result of their evolutionary origin from a common ancestral gene, and it explains why they can sometimes exhibit slight cross-reactivity at each other's receptors in various tissues.

200. (D) A false but R is true
Nephrogenic diabetes insipidus is caused by the kidneys' inability to respond to antidiuretic hormone, rather than a lack of the hormone itself. This can result from defective ADH receptors or aquaporin channels. Therefore, administering exogenous ADH will not successfully treat this form of the disease, as the underlying problem is tissue resistance. The reason provided is true, but the assertion that exogenous ADH is a successful treatment is false.

201. (A) V_1 receptor
The vasoconstrictor effects of vasopressin are mediated by the V_1 receptor subtype, which is located on the surface of vascular smooth muscle cells. When vasopressin binds to these receptors, it triggers an increase in intracellular calcium, leading to muscle contraction and an increase in systemic peripheral resistance. This mechanism is particularly important for maintaining blood pressure during severe hemorrhage or other states of acute fluid loss in animals.

202. (D) Neurophysins
Neurophysins are specific carrier proteins responsible for transporting oxytocin and antidiuretic hormone from the hypothalamus to the posterior pituitary. They are synthesized alongside the hormones as part of a single large precursor molecule. During transport down the axons, the precursor is cleaved, but the neurophysins remain associated with the hormones until they are released into the blood, ensuring their stable delivery and storage within the nerve terminals.

203. (B) Vasopressin
Severe hemorrhage leads to the massive secretion of vasopressin as part of the body's emergency response to restore blood pressure and volume. In this context, the hormone acts as a powerful

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regulation of FSH levels is essential for ensuring that a healthy egg is prepared for ovulation during each cycle.

187. (A) Initiating and maintaining milk production (lactogenesis)
Prolactin is the primary hormone responsible for the initiation and maintenance of milk production, a process known as lactogenesis. It acts on the mammary alveolar epithelial cells to stimulate the synthesis of milk proteins and fats. While other hormones like oxytocin are involved in milk ejection, prolactin is essential for ensuring that an adequate supply of milk is produced and maintained throughout the lactation period in mammals.

188. (C) Pro-opiomelanocortin
Adrenocorticotropic hormone is synthesized as part of a much larger precursor protein known as pro-opiomelanocortin. In the corticotroph cells of the anterior pituitary, POMC is enzymatically cleaved into ACTH and several other biologically active peptides, including beta-endorphin and melanocyte-stimulating hormone. This shared origin allows the body to coordinate the release of multiple signaling molecules in response to stress and other physiological stimuli.

189. (D) Hypoglycemia and fasting
The secretion of growth hormone is strongly stimulated by states of hypoglycemia and fasting. When blood glucose levels fall, the body releases GH to promote the mobilization of fatty acids and reduce glucose utilization by non-essential tissues. This ensures that sufficient glucose is available for the brain and other vital organs. Conversely, high blood glucose or elevated levels of IGF-1 exert negative feedback to inhibit GH release.

190. (A) P-4, Q-1, R-3, S-2
TSH targets the thyroid follicular cells to regulate metabolism, while ACTH stimulates the zona fasciculata of the adrenal cortex to produce cortisol. FSH acts on the granulosa cells of the ovary to promote follicle development, and prolactin targets the mammary alveolar epithelium to initiate milk production. These specific hormone-receptor interactions are fundamental to the coordination of the endocrine system and the maintenance of health in animals.

191. (B) Acromegaly
Acromegaly is a condition that occurs when there is excessive secretion of growth hormone after the closure of the epiphyseal plates in an adult animal. Because the long bones can no longer grow in length, the excess GH causes the thickening of bones and the overgrowth of soft tissues, particularly in the face, paws, and internal organs. This disorder is often caused by a functional pituitary tumor and can lead to significant health complications.

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192. (B) Beta-endorphin
The cleavage of the pro-opiomelanocortin precursor peptide in the anterior pituitary produces ACTH along with other biologically active fragments, most notably beta-endorphin. Beta-endorphin is an endogenous opioid that plays a role in pain modulation and the response to stress. This simultaneous release of a stress-regulating hormone and a natural painkiller demonstrate the integrated way the body manages its response to challenging environmental and physiological conditions.

193. (A) Storing and releasing hormones synthesized in the hypothalamus
The posterior pituitary, also known as the neurohypophysis, is distinct because it does not synthesize its own hormones. Instead, it serves as a storage and release site for oxytocin and antidiuretic hormone, which are produced by neurons in the hypothalamus. These hormones are transported down axons to the posterior pituitary and released into the blood in response to neural signals, allowing for rapid physiological responses to changes in hydration and reproductive needs.

194. (C) An increase in plasma osmolality
The primary trigger for the release of antidiuretic hormone is an increase in plasma osmolality, which is detected by specialized osmoreceptors in the hypothalamus. Even small changes in the concentration of solutes in the blood can stimulate the secretion of ADH. Once released, ADH acts on the kidneys to increase water reabsorption, helping to dilute the blood and restore normal osmolality and fluid balance throughout the animal body.

212. (C) Na^+/K^+ ATPase pumps
Thyroid hormones increase the basal metabolic rate primarily by stimulating the synthesis and activity of sodium-potassium ATPase pumps in nearly all tissues. These pumps consume a significant amount of cellular ATP to maintain electrochemical gradients across the plasma membrane. By increasing the number of these pumps, thyroid hormones enhance oxygen consumption and heat production, which are the hallmark characteristics of a higher metabolic state in animals.

213. (A) The Na^+/K^+ ATPase sodium concentration gradient
The sodium-iodide symporter is the protein responsible for the active transport of iodide into the thyroid follicular cells. This transport process is driven by the sodium concentration gradient created by the Na^+/K^+ ATPase pump, which is a form of secondary active transport. By concentrating iodide within the gland, the NIS ensures that there is a sufficient supply of the element for the continuous synthesis of thyroid hormones even when dietary intake is low.

214. (D) The anterior pituitary (thyrotrophs) and the hypothalamus
High levels of circulating thyroid hormones regulate their own production through a negative feedback loop that targets both the hypothalamus and the anterior pituitary. T_3 and T_4 inhibit the release of TRH from the hypothalamus and TSH from the thyrotrophs in the pituitary. This regulatory mechanism ensures that the concentration of thyroid hormones in the blood is kept within a narrow range, preventing the harmful effects of hyperthyroidism or hypothyroidism.

215. (B) Central nervous system (CNS)
Thyroid hormones play a critical role in the developmental maturation of the central nervous system in neonatal mammals. They are essential for processes such as neuronal migration, myelination, and the development of synapses. A deficiency of thyroid hormone during early life can lead to irreversible neurological damage and developmental delays. This is why monitoring and ensuring adequate iodine intake and thyroid function is vital for the health of growing offspring.

216. (C) Inhibiting the uptake and organification of iodine
Goitrogens are naturally occurring compounds that cause goiter by inhibiting the uptake and organification of iodine by the thyroid gland. They are found in high concentrations in certain plants, such as brassicas and cassava. By interfering with thyroid hormone synthesis, these substances cause a compensatory increase in TSH levels, which stimulates the growth of the thyroid gland. This results in the characteristic swelling of the neck seen in affected animals and humans.

217. (D) Iodine
Endemic goiter in domestic animals is most strongly correlated with a dietary deficiency of iodine in specific geographic regions where the soil and water lack the mineral. Without sufficient iodine, the thyroid gland cannot synthesize enough hormones, leading to a breakdown of the negative feedback loop. The resulting increase in TSH causes the gland to enlarge as it attempts to capture every available atom of iodine, forming a goiter.

218. (A) Lethargy, weight gain, alopecia, and cold intolerance
Hypothyroidism is a common endocrine disorder in dogs, typically presenting with lethargy, weight gain, symmetrical alopecia, and cold intolerance. These signs reflect a general slowing of the metabolic rate and impaired tissue maintenance. Affected dogs may also exhibit a dull coat, thickened skin, and a tragic facial expression. This condition is usually caused by autoimmune destruction of the thyroid gland and can be successfully managed with lifelong hormone replacement therapy.

219. (B) Weight loss despite a ravenous appetite (polyphagia)
Hyperthyroidism is a common condition in older cats, usually caused by benign adenomatous hyperplasia of the thyroid gland. The hallmark clinical sign is significant weight loss despite a ravenous appetite, as the excess hormones dramatically increase the basal metabolic rate. Other symptoms include hyperactivity, tachycardia, and a poor hair coat. If left untreated, hyperthyroidism can lead to serious cardiovascular and renal complications in affected feline patients.

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osteoid matrix in adult animals. Unlike rickets, which affects the growth plates of young animals, osteomalacia occurs in mature skeletons where bone remodeling is still ongoing. It is typically caused by a deficiency of vitamin D or phosphorus, leading to softened bones that are prone to deformities and fractures. This condition results in significant skeletal pain and lameness in affected individuals.

253. (D) Zona glomerulosa
The zona glomerulosa is the outermost layer of the adrenal cortex and is responsible for the synthesis and secretion of mineralocorticoids, primarily aldosterone. This zone lacks the enzymes necessary for producing glucocorticoids or sex hormones, specializing instead in the regulation of electrolyte balance. Aldosterone secreted from this region plays a vital role in maintaining blood pressure and fluid volume by controlling the renal handling of sodium and potassium in various animal species.

254. (D) Increasing sodium reabsorption and promoting potassium excretion
The primary physiological role of aldosterone is to increase the reabsorption of sodium and the excretion of potassium in the renal distal tubules and collecting ducts. By stimulating the production of sodium channels and pumps, aldosterone enhances the movement of sodium from the tubule lumen into the blood, which also draws water back through osmosis. This mechanism is essential for regulating systemic blood pressure, extracellular fluid volume, and the maintenance of normal electrolyte concentrations.

255. (A) Cortisol
Cortisol is the most potent and prevalent naturally occurring glucocorticoid in many mammalian species, including dogs and pigs. It is synthesized in the zona fasciculata of the adrenal cortex and is released in response to ACTH. Cortisol plays a vital role in the body's response to stress by regulating the metabolism of carbohydrates, proteins, and fats. It also possesses significant anti-inflammatory and immunosuppressive properties that influence overall health and systemic homeostasis.

256. (D) Stimulate gluconeogenesis, lipolysis, and protein catabolism
During periods of stress, glucocorticoids act to increase the availability of metabolic fuels by stimulating gluconeogenesis in the liver and promoting the catabolism of proteins and fats. By breaking down muscle proteins into amino acids and adipose tissue into fatty acids, they provide the necessary substrates for glucose production. This "catabolic" effect ensures that the brain has a steady supply of energy while also modulating the body's overall inflammatory and immune responses.

257. (B) Phenylethanolamine N-methyltransferase (PNMT)
The enzyme phenylethanolamine N-methyltransferase is uniquely present in high concentrations within the adrenal medulla. It catalyzes the final step in the synthesis of epinephrine by transferring a methyl group to norepinephrine. The activity of PNMT is stimulated by glucocorticoids that reach the medulla from the surrounding adrenal cortex. This enzyme allows the adrenal gland to produce large amounts of epinephrine, the primary hormone responsible for the systemic "fight-or-flight" response in animals.

258. (D) Hypovolemia or reduced renal perfusion
The secretion of aldosterone is primarily triggered by the renin-angiotensin-aldosterone system in response to hypovolemia or reduced renal perfusion. When the kidneys detect a drop in blood pressure or sodium levels, they release renin, which ultimately leads to the production of angiotensin II. Angiotensin II then stimulates the zona glomerulosa of the adrenal cortex to secrete aldosterone, which works to restore blood volume and pressure by increasing renal sodium and water reabsorption.

259. (A) Alpha and Beta adrenergic receptors
Catecholamines like epinephrine and norepinephrine from the adrenal medulla orchestrate the "fight-or-flight" response by binding to alpha and beta adrenergic receptors throughout the body. These receptors are located on smooth muscle, cardiac muscle, and metabolic tissues, where they trigger responses such as increased heart rate, vasodilation in skeletal muscle, and the mobilization of energy stores. This rapid activation prepares the animal

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228. (A) Hypercholesterolemia
In hypothyroidism, the reduction in thyroid hormone levels leads to changes in lipid metabolism, characteristically resulting in hypercholesterolemia. Thyroid hormones are essential for the expression of LDL receptors on hepatocytes, which allow the liver to clear cholesterol from the blood. When these hormones are deficient, the clearance of cholesterol is impaired, leading to elevated systemic levels. This finding is a common biochemical indicator used to support a diagnosis of hypothyroidism.

229. (B) Increase blood calcium and decrease blood phosphate
The main physiological function of parathyroid hormone is to increase blood calcium levels while decreasing blood phosphate concentrations. PTH achieves this by stimulating the release of calcium from bone, increasing renal calcium reabsorption, and enhancing the renal excretion of phosphate. These coordinated actions ensure that ionized calcium levels are maintained within a very narrow range, which is critical for nerve and muscle function throughout the body.

230. (B) Hypocalcemia
Parathyroid hormone is secreted by the chief cells of the parathyroid gland in direct response to hypocalcemia. The cells possess specialized calcium-sensing receptors that detect even small decreases in extracellular ionized calcium. When calcium levels fall, the receptors signal the immediate release of preformed PTH into the blood. This rapid response is essential for initiating the homeostatic mechanisms that restore normal calcium levels and prevent the harmful effects of low blood calcium.

231. (B) Thyroid parafollicular (C) cells
Calcitonin is a hormone that acts to lower blood calcium levels and is synthesized and secreted by the parafollicular cells, also known as C-cells, of the thyroid gland. These cells respond to hypercalcemia by releasing calcitonin, which inhibits bone resorption and increases renal calcium excretion. Although its role in daily calcium regulation is less dominant than that of PTH, calcitonin is important for protecting the skeleton during periods of high calcium intake.

232. (D) 1-alpha-hydroxylase
In the kidney, parathyroid hormone strongly stimulates the activity of the enzyme 1-alpha-hydroxylase. This enzyme is responsible for the final step in the synthesis of active vitamin D, converting 25-hydroxycholecalciferol into 1,25-dihydroxycholecalciferol. By increasing the production of active vitamin D, PTH indirectly enhances the intestinal absorption of calcium and phosphorus, further contributing to the maintenance of systemic mineral levels in response to hypocalcemia in animals.

233. (A) Increasing intestinal absorption of calcium and phosphorus
The principal action of active vitamin D is to increase the intestinal absorption of both calcium and phosphorus. It achieves this by binding to nuclear receptors in the enterocytes, which upregulates the synthesis of calcium-binding proteins and transporters. This mechanism ensures that the body can efficiently capture these minerals from the diet, providing the necessary building blocks for bone health and the maintenance of essential extracellular mineral concentrations.

234. (D) Osteoclasts
At the level of the bone, parathyroid hormone binds to receptors on osteoblasts, stimulating them to secrete factors like RANKL. These factors then activate osteoclasts, which are the cells responsible for bone resorption. By breaking down the mineralized bone matrix, osteoclasts release calcium and phosphate into the systemic circulation. This process is a key part of the systemic response to hypocalcemia, providing a rapid source of calcium to restore blood levels.

235. (B) It inhibits phosphate reabsorption, causing phosphaturia
Parathyroid hormone has a significant effect on renal phosphate handling by inhibiting the reabsorption of phosphate in the proximal tubule. This leads to an increase in the amount of phosphate excreted in the urine, a condition known as phosphaturia. By lowering blood phosphate levels, PTH prevents the formation of insoluble calcium-phosphate complexes in the blood, ensuring that the released calcium remains in its active, ionized form for use by tissues.

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236. (B) G-protein coupled receptor (GPCR)
The calcium-sensing receptor on the parathyroid gland belongs to the family of G-protein coupled receptors. It is uniquely designed to detect small changes in the concentration of extracellular

ionized calcium. When calcium binds to the receptor, it triggers an intracellular signaling cascade that inhibits the secretion of parathyroid hormone. This allows the gland to precisely monitor and respond to systemic calcium levels, maintaining homeostasis through a very sensitive negative feedback mechanism.

237. (A) Using a nuclear receptor to upregulate calcium-binding proteins
Active vitamin D exerts its biological effects in the intestine by binding to a specific nuclear receptor, which then acts as a transcription factor. This interaction leads to the upregulation of genes encoding for calcium-binding proteins, such as calbindin, and specialized calcium transporters. By increasing the expression of these proteins, vitamin D enhances the efficiency of calcium uptake from the gut lumen into the systemic circulation to support systemic mineral needs.

238. (D) Inhibiting osteoclast-mediated bone resorption
Calcitonin regulates calcium levels primarily by inhibiting the activity of osteoclasts, the cells responsible for bone resorption. When blood calcium levels are high, calcitonin is released and binds to receptors on the osteoclasts, causing them to shrink and stop their resorptive activity. This rapidly reduces the release of calcium from the skeleton into the blood, helping to restore normal mineral levels and protect the bones from excessive degradation during periods of hypercalcemia.

239. (D) Working synergistically to maintain extracellular calcium levels
The interplay between parathyroid hormone and active vitamin D is essential because they work synergistically to maintain extracellular calcium levels within a narrow range. PTH stimulates the release of calcium from bone and increases its renal reabsorption, while also triggering the production of active vitamin D. Vitamin D, in turn, enhances the intestinal absorption of calcium and phosphorus. Together, these two hormones ensure that the body's mineral needs are met through multiple pathways.

240. (A) III, II, V, I, IV
In response to acute hypocalcemia, the body follows a precise sequence to restore balance. First, the decreased binding of calcium to the calcium-sensing receptors on the parathyroid gland triggers the release of PTH. This hormone then stimulates the activation of 1-alpha-hydroxylase in the kidney, producing active vitamin D. Together, they increase bone resorption and renal calcium reabsorption, ultimately leading to the restoration of normal blood calcium levels in the animal.

241. (A) Acute hypocalcemia due to massive calcium drain into milk
Parturient paresis, commonly known as milk fever, is a metabolic disorder in dairy cows characterized by acute hypocalcemia at the onset of lactation. The sudden, massive drain of calcium into the milk exceeds the cow's ability to mobilize enough mineral from her skeletal stores or absorb it from the gut. This leads to a rapid drop in blood calcium levels, resulting in muscle weakness, flaccid paralysis, and potential collapse if not treated promptly.

242. (D) Requirement of calcium for ACh release at neuromuscular junctions
Milk fever causes flaccid paralysis in cows because calcium is absolutely required for the release of acetylcholine from the presynaptic nerve terminals at the neuromuscular junction. When extracellular calcium levels are critically low, the nerve signal cannot be transmitted to the muscle, leading to profound muscle weakness. In contrast, hypocalcemia in dogs often leads to tetany due to a decrease in the threshold for action potential generation in sensory and motor nerves.

243. (A) Low in calcium and high in phosphorus
Nutritional secondary hyperparathyroidism is most classically caused by a diet that is chronically low in calcium and excessively high in phosphorus. The resulting low blood calcium levels trigger the continuous secretion of parathyroid hormone, which leads to the progressive resorption of bone to maintain mineral homeostasis. This condition is often seen in animals fed unsupplemented meat or grain diets, resulting in weakened, fragile bones and skeletal deformities over time.

244. (D) Nutritional secondary hyperparathyroidism
A diet consisting entirely of unsupplemented meat fed to domestic cats typically results in nutritional secondary hyperparathyroidism because meat is naturally very low in calcium

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and high in phosphorus. This imbalance leads to chronic hypocalcemia, which stimulates the parathyroid glands to overproduce PTH. The resulting excessive bone resorption can cause significant skeletal problems, including spontaneous fractures and the loss of bone density in the jaw, a condition often called "rubber jaw."

245. (B) Phytate and Phosphorus
Bran disease, or osteodystrophia fibrosa, in horses is a form of nutritional secondary hyperparathyroidism caused by diets containing excessive wheat bran. Bran is very high in phosphorus and phytates, which can bind dietary calcium and prevent its absorption. The resulting mineral imbalance leads to the chronic overstimulation of the parathyroid glands and the progressive replacement of bone tissue with fibrous connective tissue, particularly in the bones of the face and skull.

246. (D) Reduced 1,25-dihydroxycholecalciferol synthesis and phosphate retention
Renal secondary hyperparhythroidism occurs in chronic kidney disease primarily because the failing kidneys cannot properly excrete phosphate or synthesize active vitamin D. The resulting hyperphosphatemia and low levels of 1,25-dihydroxycholecalciferol lead to a decrease in ionized blood calcium. This stimulates the parathyroid glands to chronically secrete PTH, which resorbs bone in a futile attempt to normalize calcium levels, leading to severe skeletal demineralization and bone pain in affected animals.

247. (B) Hypocalcemia
Eclampsia in lactating bitches and queens, also known as puerperal tetany, is caused by acute hypocalcemia due to the heavy demand for calcium during nursing. Unlike the flaccid paralysis seen in cows, the low blood calcium in dogs and cats increases nerve excitability, leading to muscle tremors, panting, and seizures. This life-threatening condition requires immediate intravenous calcium supplementation to stabilize the animal and restore normal neuromuscular function and metabolic health.

248. (D) Inducing mild metabolic acidosis to enhance tissue sensitivity to PTH
The administration of anionic salts to pre-partum dairy cows helps prevent milk fever by inducing a state of mild metabolic acidosis. This acidic environment enhances the sensitivity of the bones and kidneys to the action of parathyroid hormone. By improving the efficiency of calcium mobilization from skeletal stores and absorption from the gut before calving, the cow is better prepared to meet the sudden increase in calcium demand at the onset of lactation.

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249. (A) Hypercalcemia and hypophosphatemia
Primary hyperparathyroidism is typically caused by a functional parathyroid adenoma that secretes excessive amounts of PTH regardless of blood calcium levels. The resulting biochemical profile characteristically shows hypercalcemia and hypophosphatemia. The high PTH levels cause excessive bone resorption and renal calcium reabsorption while also increasing phosphate excretion. This condition can lead to various complications, including kidney stones, muscle weakness, and bone fractures, as systemic mineral balance is severely disrupted.

250. (A) P-4, Q-1, R-3, S-2
Milk fever is characterized by acute hypocalcemia at the onset of lactation, while renal osteodystrophy can cause the "rubber jaw" condition in dogs with chronic kidney failure. Bran disease is a form of secondary hyperparathyroidism in horses caused by high phosphorus diets. Primary hyperparathyroidism typically involves a parathyroid adenoma that leads to hypercalcemia. Understanding these specific mineral metabolism disorders is vital for the proper diagnosis and treatment of skeletal and metabolic diseases.

251. (D) Metabolic Bone Disease
Metabolic bone disease is common in reptiles like iguanas when they are kept indoors without adequate UVB light or dietary vitamin D and calcium supplements. The lack of UVB prevents the natural cutaneous synthesis of vitamin D, leading to impaired calcium absorption and chronic secondary hyperparathyroidism. This results in the weakening of the skeleton, characterized by swollen, soft limbs and spontaneous fractures, which significantly compromises the animal's health and mobility.

252. (C) Defective mineralization of newly formed osteoid matrix in adult animals
The term osteomalacia specifically refers to the defective mineralization of the newly formed

to enlarge. Together, these changes result in the classic "potbellied" appearance that is often a hallmark of the disease.

268. (D) Hyperglycemia, hypercholesterolemia, and elevated ALP
Typical blood profile abnormalities in an animal with hyperadrenocorticism include hyperglycemia, hypercholesterolemia, and significantly elevated levels of alkaline phosphatase. Cortisol's effects on glucose and lipid metabolism lead to increased blood sugar and cholesterol. Furthermore, in dogs, excess cortisol induces a specific isoenzyme of ALP in the liver. These biochemical findings, combined with clinical signs like polyuria and alopecia, strongly suggest a diagnosis of Cushing's syndrome and warrant further specialized endocrine testing for confirmation.

269. (A) Deficiency in both mineralocorticoids and glucocorticoids
Hypoadrenocorticism, or Addison's disease, typically involves the progressive autoimmune destruction of all three zones of the adrenal cortex. This leads to a critical deficiency in both mineralocorticoids and glucocorticoids. The lack of aldosterone results in severe electrolyte imbalances and dehydration, while the deficiency in cortisol impairs the animal's ability to maintain blood glucose and respond to stress. This condition is life-threatening and requires lifelong replacement of both types of hormones to ensure survival and health.

270. (D) Hyponatremia and Hyperkalemia
The classic electrolyte imbalance associated with a severe Addisonian crisis is hyponatremia and hyperkalemia. This results from the absolute deficiency of aldosterone, which is required for the renal reabsorption of sodium and the excretion of potassium. The loss of sodium leads to hypovolemia and hypotension, while the high potassium levels can cause life-threatening cardiac arrhythmias. Recognizing and rapidly correcting these imbalances is the primary goal of emergency treatment for an animal in an acute Addisonian crisis.

271. (A) Chronic high-dose exogenous glucocorticoid administration
Iatrogenic hyperadrenocorticism is caused by the chronic administration of high-dose exogenous glucocorticoids for the treatment of various inflammatory or autoimmune conditions. These drugs mimic the effects of natural cortisol, leading to the clinical signs of Cushing's syndrome. Paradoxically, the high levels of exogenous steroids also suppress the animal's own hypothalamic-pituitary-adrenal axis, causing the natural adrenal glands to atrophy. This means the animal becomes dependent on the medication while simultaneously suffering from its excessive systemic effects.

272. (D) Iatrogenic Addisonian crisis due to severe adrenal atrophy
If a dog with iatrogenic hyperadrenocorticism has its glucocorticoid therapy stopped abruptly, it is at high risk of an acute Addisonian crisis. This occurs because the exogenous steroids have suppressed the animal's own adrenal glands, causing them to atrophy and stop producing natural cortisol. Without the medication or functional adrenal glands, the body cannot meet its basic need for glucocorticoids, especially during stress. To prevent this, steroid therapy must always be tapered slowly to allow the adrenals to recover.

273. (A) High-dose or low-dose dexamethasone suppression test
The dexamethasone suppression test is a primary screening and differentiation tool for hyperadrenocorticism. A low dose of dexamethasone is used to screen for the presence of the disease, while a high dose can often help differentiate between pituitary-dependent and adrenal-dependent forms. Dexamethasone acts like cortisol to suppress ACTH secretion in normal animals. By measuring how the adrenal glands respond to this suppression, veterinarians can determine the source of the excessive cortisol production and choose the appropriate treatment.

274. (D) Profound and sustained suppression of endogenous cortisol
In a normal animal, the administration of a low dose of dexamethasone should lead to the profound and sustained suppression of endogenous cortisol production. This occurs because dexamethasone provides negative feedback to the hypothalamus and pituitary, inhibiting the release of CRH and ACTH. In contrast, animals with hyperadrenocorticism will show little to no suppression, as the source of their cortisol or ACTH production is

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for immediate physical activity in response to a perceived threat or stressor.

260. (A) Both A and R are true and R is the correct explanation of A
Cortisol is essential for survival during prolonged starvation because it ensures that the brain has an adequate supply of glucose. It acts permissively by enhancing the effects of other hormones like glucagon and epinephrine, which stimulate gluconeogenesis in the liver. Without cortisol, the body's ability to produce glucose from non-carbohydrate sources is severely impaired, leading to life-threatening hypoglycemia. This metabolic cooperation is a critical part of the systemic adaptation to fasting and chronic stress.

261. (A) Phospholipase A_2 and COX-2
The anti-inflammatory effects of pharmacological doses of glucocorticoids are largely mediated by the inhibition of key enzymes like phospholipase A_2 and cyclooxygenase-2. By blocking these pathways, glucocorticoids reduce the production of pro-inflammatory mediators such as prostaglandins and leukatrienes. Additionally, they inhibit the migration of leukocytes to the site of inflammation and suppress the production of various cytokines, making them powerful tools for managing allergic and autoimmune diseases in veterinary medicine.

262. (D) Corticosterone
In the zona glomerulosa of the adrenal cortex, corticosterone serves as the direct substrate for the enzyme aldosterone synthase. Through a series of hydroxylation and oxidation reactions, this enzyme converts corticosterone into aldosterone, the primary mineralocorticoid. While corticosterone itself has some glucocorticoid and mineralocorticoid activity, its conversion to aldosterone is essential for the precise regulation of sodium and potassium balance and the long-term maintenance of systemic blood pressure in animals.

263. (B) Beta-2 adrenergic receptor
Epinephrine stimulates hepatic glycogenolysis by binding to beta-2 adrenergic receptors on the surface of hepatocytes. This binding activates a G-protein that stimulates adenylate cyclase to produce cyclic AMP, which then initiates a signaling cascade that activates glycogen phosphorylase. This process leads to the rapid breakdown of glycogen into glucose, which is released into the blood to provide immediate energy for the body during periods of acute stress or physical exertion.

NODIA

264. (D) Corticosterone
In birds and rodents, corticosterone is the primary functional glucocorticoid secreted by the adrenal cortex, playing the same metabolic and stress-related roles that cortisol does in dogs, humans, and other large mammals. These species have lower levels of the enzyme 17-alpha-hydroxylase in their adrenal glands, which biases the biosynthetic pathway toward corticosterone production. Despite the structural difference, its physiological effects on gluconeogenesis and immune function are largely identical to those of cortisol.

265. (D) Dogs
Hyperadrenocorticism, commonly known as Cushing's syndrome, is one of the most frequently diagnosed endocrine disorders in dogs. It results from the chronic overproduction of cortisol by the adrenal glands, which can be caused by either a pituitary tumor or a primary adrenal tumor. The disease affects many organ systems, leading to a wide range of clinical signs that progress over time. Managing canine Cushing's requires careful diagnosis and lifelong treatment to improve the animal's quality of life.

266. (C) ACTH
Pituitary-dependent hyperadrenocorticism is characterized by a functional microadenoma in the anterior pituitary that excessively secretes adrenocorticotropic hormone. The high levels of ACTH persistently stimulate both adrenal glands to grow and secrete excessive amounts of cortisol. This is the most common form of naturally occurring Cushing's syndrome in dogs. Because the tumor does not respond to normal negative feedback mechanisms, the body remains in a chronic state of hypercortisolemia, leading to the various clinical signs of the disease.

267. (A) Hepatomegaly and muscle weakness/wasting
The characteristic pendulous abdomen seen in dogs with Cushing's syndrome is caused by a combination of hepatomegaly and significant muscle wasting. Excess cortisol promotes the catabolism of proteins in skeletal muscle, leading to weakness and the sagging of the abdominal wall. Simultaneously, it stimulates the accumulation of glycogen and fat in the liver, causing the organ

depolarization of the cell, which opens voltage-gated calcium channels. The influx of calcium then triggers the exocytosis of insulin-containing vesicles. This elegant sensing mechanism ensures that insulin release is precisely coordinated with blood glucose concentrations in the animal.

283. (A) Type 1 Diabetes (absolute insulin deficiency)
Diabetes mellitus in dogs is most analogous to Type 1 diabetes in humans, characterized by an absolute deficiency of insulin. This typically results from the autoimmune destruction of the pancreatic beta cells or severe chronic pancreatitis. Because these dogs produce little to no insulin, they are completely dependent on exogenous insulin injections for survival. Unlike cats or humans with Type 2 diabetes, dietary management alone is never sufficient to control the disease in canine patients.

284. (D) Type 2 Diabetes
Feline diabetes mellitus is most similar to Type 2 diabetes in humans because it involves a combination of insulin resistance and beta-cell dysfunction. Obesity and physical inactivity are major risk factors that lead to impaired insulin signaling in tissues. Over time, the chronic demand for high insulin levels can lead to the exhaustion and damage of the pancreatic beta cells, often exacerbated by the deposition of amyloid. Many diabetic cats can achieve remission with early aggressive insulin treatment and diet.

285. (A) Polyuria, polydipsia, and polyphagia with weight loss
The classic triad of clinical signs for an animal with uncomplicated diabetes mellitus is polyuria, polydipsia, and polyphagia accompanied by weight loss. The high blood glucose levels exceed the renal threshold, leading to glycosuria and osmotic diuresis. This causes increased urination and thirst. Despite eating more, the animal loses weight because it cannot effectively utilize glucose for energy and must instead break down muscle and fat stores, highlighting the profound metabolic disruption caused by insulin deficiency.

286. (C) Acetyl-CoA derived from massive fatty acid oxidation
Diabetic ketoacidosis is a severe complication of untreated diabetes where the liver synthesizes large quantities of ketone bodies. This occurs because the absolute lack of insulin leads to unrestrained lipolysis, flooding the liver with fatty acids. These fatty acids undergo massive beta-oxidation, producing an excess of acetyl-CoA that exceeds the capacity of the citric acid cycle. The liver then converts this surplus acetyl-CoA into acetoacetate and beta-hydroxybutyrate, which are acidic and lead to metabolic acidosis.

287. (C) Acetone
Acetone is a volatile ketone body produced by the spontaneous decarboxylation of acetoacetate during periods of severe ketosis. Because it is highly volatile, it is excreted through the lungs and imparts a characteristic fruity or sweet odor to the breath of animals suffering from diabetic ketoacidosis. While acetone itself does not contribute significantly to metabolic acidosis like other ketone bodies, its presence is a hallmark sign of a critical state of metabolic imbalance and energy crisis.

288. (B) Bilateral cataracts
A common and rapid complication of diabetes mellitus in dogs is the formation of bilateral cataracts. High blood glucose levels lead to the accumulation of sorbitol within the lens of the eye through the action of the enzyme aldose reductase. Sorbitol is osmotically active and draws water into the lens fibers, causing them to swell and rupture. This process leads to the rapid development of opacity and eventual blindness, often occurring within months of the onset of diabetes.

289. (B) Melatonin
The pineal gland acts as a neuroendocrine transducer by converting neural signals about the photoperiod into the secretion of melatonin. During the night, the lack of light stimulation allows the pinealocytes to synthesize and release melatonin into the systemic circulation. This hormone provides the body with a biological signal of darkness, which is essential for coordinating circadian rhythms and seasonal reproductive cycles in many domestic and wild animal species across the globe.

290. (C) High levels during the night and low levels during the day
Melatonin secretion exhibits a very consistent circadian rhythm characterized by high levels during the night and very low levels during the day. This pattern is maintained by an internal clock in the hypothalamus that is synchronized

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independent of normal regulatory control, which is a key diagnostic feature.

275. (D) Antagonizes the action of ADH at the renal tubules
Animals with Cushing's disease frequently exhibit polyuria and polydipsia primarily because excess cortisol antagonizes the action of antidiuretic hormone at the level of the renal tubules. Cortisol interferes with the insertion of aquaporin channels, making the kidneys less responsive to ADH. This results in the production of a large volume of dilute urine, which then triggers a compensatory increase in thirst. This symptom is one of the most common and earliest signs observed by owners of dogs with the disease.

276. (B) Hirsutism (hypertrichosis), laminitis, and lethargy
Equine Pituitary Pars Intermedia Dysfunction, formerly called Equine Cushing's, classically presents with hirsutism, laminitis, and lethargy. Hirsutism, or the failure to shed the winter coat, is the most recognizable sign and is caused by the overproduction of several POMC-derived peptides. These peptides also contribute to metabolic changes that increase the risk of laminitis, a painful and debilitating foot condition. PPID is caused by the loss of dopaminergic inhibition of the pituitary pars intermedia in older horses.

277. (B) Beta cells
The beta cells are the most numerous cell type in the pancreatic Islets of Langerhans and are responsible for the synthesis and secretion of insulin. These cells act as metabolic sensors, releasing insulin in response to elevated blood glucose levels. Insulin is the primary anabolic hormone that promotes the storage of energy and the uptake of nutrients by tissues. The healthy function of beta cells is essential for maintaining systemic glucose homeostasis and preventing the development of diabetes mellitus.

278. (B) Facilitating glucose entry into muscle and fat via $GLUT_4$ transporters
Insulin's major metabolic effect on carbohydrate metabolism is to facilitate the entry of glucose into skeletal muscle and adipose tissue. It achieves this by stimulating the translocation of $GLUT_4$ glucose transporters from intracellular vesicles to the plasma membrane. This process rapidly increases the rate of glucose uptake, allowing these tissues to use or store the sugar and effectively lowering blood glucose levels. This mechanism is the primary way the body manages postprandial glucose spikes in animals.

279. (B) Hepatic glycogenolysis and gluconeogenesis
Glucagon is secreted by the alpha cells of the pancreas and acts as the primary counter-regulatory hormone to insulin. Its principal function is to elevate blood glucose levels during periods of fasting by stimulating hepatic glycogenolysis and gluconeogenesis. By breaking down stored glycogen and synthesizing new glucose from amino acids and glycerol, glucagon ensures a steady supply of energy for the brain. Its action is vital for maintaining glucose homeostasis between meals and during physical activity.

280. (B) Inhibiting the secretion of both insulin and glucagon
Somatostatin, secreted by the pancreatic delta cells, functions as a local paracrine regulator that inhibits the secretion of both insulin and glucagon. This allows for the fine-tuning of the endocrine response to nutrient intake, preventing excessive fluctuations in blood glucose levels. By modulating the activity of the neighboring alpha and beta cells, somatostatin plays a critical role in the integrated control of systemic metabolism and the overall efficiency of nutrient utilization within the animal body.

281. (A) Connecting peptide (C-peptide)
Insulin is synthesized as a single-chain precursor called proinsulin, which is cleaved in the secretory granules into active insulin and a connecting peptide, known as C-peptide. Both molecules are released into the systemic circulation in equimolar amounts. While C-peptide has little known metabolic activity, measuring its levels in the blood can be a useful diagnostic tool to assess the endogenous secretory capacity of the pancreatic beta cells, especially in diabetic animals receiving exogenous insulin therapy.

282. (B) ATP-sensitive potassium channels
The mechanism of insulin secretion involves glucose entering the beta cell and being metabolized to produce ATP. The resulting increase in the ATP-to-ADP ratio causes the closure of ATP-sensitive potassium channels in the plasma membrane. This leads to the

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220. (B) Glycosaminoglycans like hyaluronic acid and chondroitin sulfate
Myxedema is a feature of severe hypothyroidism that involves the accumulation of glycosaminoglycans, such as hyaluronic acid and chondroitin sulfate, in the dermal tissues. These substances attract water, leading to the characteristic non-pitting edema and thickening of the skin. In animals, this can result in a swollen, puffy appearance, particularly around the face and eyes, and is a sign of long-standing and profound thyroid hormone deficiency.

221. (A) Low T_4, High TSH
Primary hypothyroidism occurs when the defect lies within the thyroid gland itself, preventing the production of thyroxine. In this condition, the blood profile characteristically shows low T_4 levels and high TSH levels. The lack of negative feedback from T_4 leads the anterior pituitary to secrete more TSH in a futile attempt to stimulate the failing gland. This hormone profile is the primary diagnostic indicator for the most common form of hypothyroidism.

222. (D) Cretinism
Cretinism is a severe developmental syndrome in offspring that results from congenital hypothyroidism, often caused by iodine deficiency during pregnancy. It is characterized by stunted growth, mental retardation, and skeletal abnormalities. Because thyroid hormones are essential for the normal development of the brain and skeleton, their absence during critical fetal and neonatal periods causes irreversible physical and cognitive impairments that cannot be fully corrected with later treatment.

223. (A) Benign adenomatous hyperplasia (adenoma) of the thyroid gland
Feline hyperthyroidism typically results from benign adenomatous hyperplasia or an adenoma of the thyroid gland. These functional tumors secrete excessive amounts of thyroid hormones, independent of TSH control. This overproduction leads to a state of hypermetabolism that affects nearly every organ system in the cat's body. While thyroid carcinomas are rare, the benign form is very common in older cats and requires medical, surgical, or radioactive iodine treatment to manage.

224. (D) Methimazole
Methimazole is the most commonly used pharmacological agent for the medical management of hyperthyroidism in cats. It works by inhibiting the enzyme thyroid peroxidase, which is responsible for the iodination and coupling steps of hormone synthesis. By blocking the production of new thyroid hormones, methimazole effectively lowers systemic T_4 and T_3 levels, alleviating the clinical signs of the disease. It must be administered daily to maintain stable hormone concentrations.

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225. (D) Anterior pituitary failure to secrete TSH
Secondary hypothyroidism is caused by a defect in the anterior pituitary that leads to a failure to secrete sufficient thyroid-stimulating hormone. Without the stimulatory signal from TSH, the thyroid gland remains inactive and produces very little thyroxine. This form of the disease is much less common than primary hypothyroidism and is usually associated with pituitary tumors or trauma. The blood profile typically shows low levels of both T_4 and TSH.

226. (A) T_3 upregulates myocardial beta-adrenergic receptors
The tachycardia and increased cardiac output observed in hyperthyroidism are primarily due to triiodothyronine upregulating the number of beta-adrenergic receptors in the heart. This increases the sensitivity of the myocardium to circulating catecholamines, leading to a higher heart rate and stronger contractions. Over time, this hyperdynamic state can lead to cardiac hypertrophy and eventually heart failure if the underlying thyroid condition is not properly managed.

227. (B) Heat
The increased basal metabolic rate in hyperthyroidism is closely linked to the uncoupling of oxidative phosphorylation, which causes a significant portion of the energy produced from nutrients to be released as heat instead of being captured as ATP. This process, often mediated by uncoupling proteins, leads to the characteristic heat intolerance and excessive sweating or panting observed in hyperthyroid animals as they struggle to maintain their core body temperature.

by light signals from the eyes. The daily surge in melatonin serves as a systemic time cue, regulating sleep-wake cycles and informing the body about changes in day length, which is vital for seasonal adaptations in behavior and physiology.

291. (C) GnRH
In seasonal breeding animals, melatonin regulates reproductive cyclicity by modifying the pulsatile release of gonadotropin-releasing hormone from the hypothalamus. Changes in day length lead to variations in the duration of nightly melatonin secretion, which the animal uses to determine the proper time of year for breeding. This ensures that offspring are born during favorable environmental conditions. Depending on the species, melatonin can either stimulate or inhibit GnRH secretion to coordinate these complex reproductive seasonal transitions.

292. (B) Luteinizing Hormone (LH)
The principal testicular hormone, testosterone, is synthesized by the Leydig cells under the direct control of luteinizing hormone from the anterior pituitary. LH binds to specific receptors on the Leydig cells, triggering an intracellular cascade that increases the conversion of cholesterol into testosterone. This hormonal axis is essential for the maintenance of male fertility and secondary sexual characteristics. Adequate levels of LH are required to ensure continuous testosterone production and successful spermatogenesis throughout the animal's reproductive life.

293. (B) Estrogen (Estradiol)
Estrogens, particularly estradiol, are the gonadal hormones primarily responsible for the behavioral signs of estrus in female domestic animals. As ovarian follicles mature, they secrete increasing amounts of estrogen, which acts on the brain to induce receptivity to mating. This hormonal peak also triggers physiological changes in the reproductive tract, such as increased mucus secretion and uterine tone, to prepare for potential fertilization. The coordination of these behavioral and physical signals is essential for successful breeding and reproduction.

294. (B) Ovarian corpus luteum following ovulation
Progesterone is synthesized and secreted primarily by the ovarian corpus luteum, which forms from the remnants of the follicle after ovulation. This hormone is essential for preparing the uterine lining for the implantation of the embryo and for the maintenance of pregnancy. By inhibiting uterine contractions and maintaining a secretory endometrium, progesterone creates a stable environment for fetal development. If pregnancy does not occur, the corpus luteum regresses, leading to a drop in progesterone and the start of a new cycle.

295. (B) FSH
Inhibin is a protein hormone produced by the Sertoli cells in males and the granulosa cells in females. Its primary function is to exert negative feedback strictly on the secretion of follicle-stimulating hormone from the anterior pituitary. By selectively inhibiting FSH without affecting LH, inhibin allows for the precise regulation of gamete development in both sexes. This feedback loop is essential for coordinating the rate of follicular growth and spermatogenesis, ensuring that reproductive processes remain balanced and efficient.

296. (B) Granulosa cells
In the two-cell, two-gonadotropin model of follicular estrogen synthesis, theca cells produce androgens in response to LH. These androgens then diffuse into the neighboring granulosa cells, where the enzyme aromatase converts them into estrogens under the influence of FSH. This cooperative mechanism is essential for producing the high levels of estrogen required for the expression of estrus and the preovulatory surge of LH. The healthy function of both cell types is critical for normal follicular development and successful ovulation.

297. (B) Softening the cervix and relaxing pelvic ligaments
Relaxin is a peptide hormone secreted during late pregnancy that facilitates the process of parturition. Its primary physiological role is to soften the connective tissues of the cervix and relax the pelvic ligaments, allowing the birth canal to expand. This action ensures that the fetus can pass through the pelvis more easily during delivery. By increasing the flexibility of these structures, relaxin reduces the risk of birth complications and supports a successful and safe labor process for the mother.

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(A) Proline
(B) Glycine
(C) Hydroxylysine
(D) Alanine

2004

10. Which enzyme is considered a standard systemic biochemical marker for osteoblast activity and bone mineralization?
(A) Acid phosphatase
(B) Alkaline phosphatase
(C) Creatine kinase
(D) Lactate dehydrogenase

2022

11. Cerebrosides, found abundantly in nerve tissue myelin, are fundamentally classified as which type of lipid?
(A) Glycosphingolipids
(B) Glycerophospholipids
(C) Complex triacylglycerols
(D) Cholesterol-based sterols

2006

12. Consider the following statements regarding adipose tissue metabolism:
I. Brown fat is primarily thermogenic.
II. White fat utilizes UCP-1 for heat production.
III. Lipolysis is stimulated by epinephrine.
IV. Insulin inhibits lipogenesis.
Which of the above statements is/are INCORRECT?
(A) I, II and III
(B) II and IV
(C) I, III and IV
(D) I and IV

2002

13. Which hormone serves as the primary stimulus for the lactogenic synthesis of milk proteins such as caseins?
(A) Oxytocin
(B) Progesterone
(C) Epinephrine
(D) Prolactin

2011

14. Which transport protein is primarily responsible for carrying absorbed iron through the mammalian bloodstream?
(A) Ferritin
(B) Hemosiderin
(C) Transferrin
(D) Ceruloplaspin

2005

15. Calcitriol regulates intestinal calcium absorption by stimulating the synthesis of which specific protein?
(A) Calmodulin
(B) Calbindin
(C) Calcitonin
(D) Calsequestrin

2021

16. The Bromosulfophthalein (BSP) clearance test is primarily utilized to evaluate the secretory capacity of which organ?
(A) Kidney
(B) Pancreas
(C) Spleen
(D) Liver

2018

17. Consider the following statements regarding renal function tests:
I. Serum creatinine is directly proportional to GFR.
II. Creatinine is a breakdown product of muscle creatine phosphate.
III. BUN levels are uninfluenced by dietary protein.
IV. GFR clearance uses freely filtered markers.
V. Inulin is considered a gold standard for GFR.
Which of the above statements is/are correct?
(A) II, IV and V
(B) I, II, IV and V
(C) I, III and IV
(D) II, III and V

NODIA

2010

18. Select the correct order of physiological events during the pathogenesis of severe ketonuria.
(A) Fat mobilization, Hepatic ketogenesis, Ketonemia, Renal excretion
(B) Hepatic ketogenesis, Fat mobilization, Ketonemia, Renal excretion
(C) Ketonemia, Fat mobilization, Hepatic ketogenesis, Renal excretion
(D) Fat mobilization, Ketonemia, Hepatic ketogenesis, Renal excretion

2006

19. Blood typing in wild animal species often presents diagnostic challenges due to the presence of naturally occurring what?
(A) Isoantibodies
(B) Autoantigens
(C) Xenobiotics
(D) Eosinophils

CHAPTER 08
Biochemistry of Blood

2007

1. Which parameter directly measures the proportion of total blood volume occupied by erythrocytes in domestic animals?
(A) Hematocrit
(B) Mean corpuscular volume
(C) Hemoglobin concentration
(D) Erythrocyte sedimentation rate

2019

2. Read the following assertion and reason and select the correct option:
Assertion (A): The Rapoport-Luebering shunt bypasses the ATP-generating step of glycolysis in erythrocytes.
Reason (R): This shunt produces 2,3-BPG which decreases hemoglobin oxygen affinity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

3. During leukocyte respiratory burst, which enzyme initially converts molecular oxygen to a superoxide anion?
(A) NADPH oxidase
(B) Myeloperoxidase
(C) Superoxide dismutase
(D) Catalase

2001

4. In plasma protein electrophoretic separation, which fraction typically migrates closest to the positive electrode (anode)?
(A) Gamma globulins
(B) Fibrinogen
(C) Beta globulins
(D) Albumin

2005

5. The Haldane effect primarily describes how oxygenation of blood in the lungs promotes which physiological process?
(A) Binding of 2,3-BPG to hemoglobin molecules
(B) Release of carbon dioxide from hemoglobin
(C) Stabilization of the T-state of hemoglobin
(D) Hydration of carbon dioxide via anhydrase

2023

6. Consider the following statements regarding physiological buffers:
I. Bicarbonate is the primary extracellular buffer.
II. Phosphate acts primarily in the intracellular fluid.
III. Proteins are ineffective at physiological pH.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II
(D) III

2013

7. Match the items in List I with those in List II and select the correct option:
List I: (Renal Acid-Base Regulation)
P. Bicarbonate reclamation
Q. Titratable acidity
R. Ammonium excretion
S. Carbonic anhydrase
List II: (Mechanism)
1. Generation of new bicarbonate via glutamine
2. Excretion of dihydrogen phosphate
3. Reabsorption of filtered buffers
4. Catalyzes hydration of CO_2
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-4, R-3, S-2

2005

8. In skeletal muscle, the Cori cycle prevents lactate accumulation by transferring it to which organ for gluconeogenesis?
(A) Liver
(B) Kidney
(C) Heart
(D) Brain

2004

9. Which amino acid occurs at every third position in the helical region of the collagen molecule?

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2024

50. A decreased Albumin:Globulin (A:G) ratio is clinically indicative of which of the following conditions?
(A) Physiological state of severe dehydration
(B) Case of acute iron toxicity
(C) Chronic inflammation or liver disease
(D) Systemic state of hypothyroidism

2016

51. The Bohr effect describes the dependency of hemoglobin's oxygen binding affinity on the concentration of which two factors?
(A) Carbon dioxide and protons
(B) Carbon monoxide and oxygen
(C) 2,3-BPG and chloride
(D) Bicarbonate and sodium

2025

52. Consider the following statements regarding the Henderson-Hasselbalch equation applications:
I. $pH = pKa + \log\left(\frac{[A^-]}{[HA]}\right)$
II. It determines the isoelectric point of plasma proteins.
III. It predicts physiological blood pH from bicarbonate and CO_2 levels.
IV. It demonstrates that buffers work best near their pKa.
Which of the above statements is/are INCORRECT?
(A) I, III and IV
(B) II
(C) II, III and IV
(D) I and II

2014

53. Renal ammonium excretion primarily involves the tubular metabolism of which specific amino acid?
(A) Alanine
(B) Glutamine
(C) Glutamate
(D) Aspartate

2006

54. Which enzyme is responsible for catalyzing the transfer of a high-energy phosphate from creatine phosphate to ADP in active muscle?
(A) Adenylate kinase
(B) Myosin ATPase
(C) Creatine kinase
(D) Hexokinase

2003

55. Elastin fundamentally differs from collagen in the extracellular matrix because it inherently lacks which characteristic structural feature?
(A) Hydroxyproline and hydroxylysine residues
(B) Cross-linking mediated via desmosine
(C) Sequence of hydrophobic amino acids
(D) Gly-X-Y triple helical structure

2011

56. Which specific non-collagenous protein is abundant in osteoid and functions to facilitate the nucleation of calcium phosphate crystals?
(A) Osteocalcin
(B) Chondroitin sulfate
(C) Keratin
(D) Fibronectin

2015

57. Consider the following statements regarding neurotransmitter metabolism:
I. Acetylcholinesterase terminates acetylcholine signaling.
II. Monoamine oxidase degrades catecholamines.
III. GABA is synthesized from glutamate.
IV. Serotonin is derived from tyrosine.
V. Dopamine is an inhibitory neurotransmitter in the spinal cord.
Which of the above statements is/are correct?
(A) I, II, III and V
(B) I, II and III
(C) I, II, IV and V
(D) II, III and V

NODIA

2002

58. The primary biochemical distinction between white and brown adipose tissue revolves around the high mitochondrial expression of which protein?
(A) Secreted leptin
(B) Thermogenin (UCP-1)
(C) Plasma adiponectin
(D) Regulatory perilipin

2009

59. Milk lipid synthesis within the mammary gland predominantly incorporates de novo synthesized fatty acids up to what chain length?
(A) C16 (Palmitic acid)
(B) C_4 (Butyric acid)
(C) C18 (Stearic acid)
(D) C_20 (Arachidonic acid)

2001

20. Which diagnostic enzyme indicator is most distinctly elevated in wildlife suffering from capture myopathy?
(A) Alkaline phosphatase
(B) Gamma-glutamyl transferase
(C) Amylase
(D) Creatine kinase

2009

21. Leukoencephalomyelopathy, a recognized progressive neurological pathobiochemical disorder, is predominantly documented in which species?
(A) Non-human primates
(B) Cheetahs
(C) Elephants
(D) Wild boars

2013

22. Arrange the sequence of events in the Cytochrome P450 monooxygenase cycle:
I. Oxygen binding
II. Substrate binding to oxidized CYP450
III. First electron transfer
IV. Product release
(A) I, II, III, IV
(B) II, III, I, IV
(C) II, I, III, IV
(D) III, II, IV, I

2009

23. Which high-energy molecule acts the primary donor for phase II glucuronidation reactions in xenobiotic detoxification?
(A) ATP-glucuronate
(B) PAPS
(C) S-adenosylmethionine
(D) UDP-glucuronic acid

2017

24. What primary effect does Evans Blue dye dilution have when utilized for hematological evaluation?
(A) Estimating total plasma volume
(B) Staining leukocytes for differential counts
(C) Determining erythrocyte fragility
(D) Measuring platelet aggregation

2002

25. Read the following assertion and reason and select the correct option:
Assertion (A): The hexose monophosphate (HMP) pathway is essential for erythrocyte survival.
Reason (R): It provides NADPH required for methemoglobin reduction.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

26. Which biochemical mediator is most directly responsible for the initiation of platelet activation and aggregation pathways?
(A) Prostacyclin
(B) Thromboxane A_2
(C) Heparin
(D) Plasmin

2025

27. Match the items in List I with those in List II and select the correct option:
List I: (Plasma Proteins)
P. Albumin
Q. Transferrin
R. Fibrinogen
S. Immunoglobulins
List II: (Functions)
1. Coagulation cascade
2. Humoral immunity
3. Oncotic pressure maintenance
4. Iron transport
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2005

28. Identify the INCORRECT statement regarding hemoglobin allosteric regulation.
(A) Increased H^+ concentration shifts the oxygen dissociation curve to the right.
(B) High 2,3-BPG levels stabilize the deoxygenated form.
(C) Binding of one oxygen molecule hinders the binding of subsequent molecules.
(D) The Bohr effect facilitates oxygen delivery to metabolically active tissues.

2004

29. Consider the following statements regarding the Henderson-Hasselbalch equation:
I. It relates pH, pKa, and the ratio of base to acid.
II. It assumes complete dissociation of weak acids.
III. It is fundamental to analyzing blood gas

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2013

72. Read the following assertion and reason and select the correct option:
Assertion (A): Macrophage phagocytosis is enhanced when particles are coated with opsonins.
Reason (R): Opsonins like IgG and C3b provide specific binding sites for macrophage surface receptors.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

73. Which plasma protein class contains the critical acute phase reactants that spike rapidly during inflammation?
(A) Specific gamma globulins
(B) Alpha and beta globulins
(C) Soluble plasma albumin
(D) Transporting prealbumin

2024

74. The allosteric binding of 2,3-bisphosphoglycerate (2,3-BPG) to the beta chains of hemoglobin is stabilized by which type of bonds?
(A) Covalent bonds
(B) Ionic (salt) bridges
(C) Disulfide bonds
(D) Hydrogen bonds

2009

75. A blood sample exposed to air before testing will typically show an artifactual shift in which parameter?
(A) Increased pH
(B) Increased pCO_2
(C) Decreased pH
(D) Decreased pO_2

2025

76. The secretion of hydrogen ions in the proximal tubule is primarily coupled with the reabsorption of which crucial ion?
(A) Potassium
(B) Calcium
(C) Sodium
(D) Chloride

2002

77. Match the items in List I with those in List II and select the correct option:
List I: (Muscle Fiber Types and Metabolism)
P. Type I fibers
Q. Type IIb fibers
R. Cori cycle
S. Myoglobin
List II: (Characteristics)
1. Glycolytic, easily fatigued
2. Oxygen storage in muscle
3. Oxidative, fatigue-resistant
4. Lactate recycling to glucose
(A) P-1, Q-3, R-4, S-2
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-2, R-3, S-4

2017

78. Which extracellular matrix glycoprotein forms multimeric networks acting as a structural scaffold for cartilage proteoglycans?
(A) Heparin
(B) Laminin
(C) Hyaluronic acid
(D) Chondronectin

2018

79. The physiological mineralization process in bone osteoid fundamentally depends on maintaining optimal local concentrations of what?
(A) Calcium and Magnesium
(B) Calcium and Phosphate
(C) Sodium and Phosphate
(D) Potassium and Calcium

2008

80. Sphingolipids constitute a major structural element of nerve myelin; which molecule serves as their core backbone?
(A) Glycerol
(B) Cholesterol
(C) Inositol
(D) Sphingosine

2016

81. Lipogenesis in adipose tissue directly converts excess acetyl-CoA into fatty acids utilizing which coenzyme derived from the HMP shunt?
(A) NADPH
(B) FADH2
(C) NADH
(D) Coenzyme Q

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2023

82. Consider the following statements concerning mammary gland metabolism:
I. Casein synthesis requires essential amino acids.

2025

39. Arrange the stages of bilirubin metabolism and excretion:
I. Bilirubin conjugation with glucuronic acid
II. Heme degradation to biliverdin
III. Excretion into bile
IV. Reduction to urobilinogen in intestine
(A) II, I, III, IV
(B) I, II, III, IV
(C) II, III, I, IV
(D) I, III, II, IV

2022

40. Blood Urea Nitrogen (BUN) levels can be factitiously elevated without renal disease by which common physiological factor?
(A) High protein diet
(B) High carbohydrate diet
(C) Vitamin C supplementation
(D) Excessive water intake

2022

41. Which pathological condition is indicated by the prominent presence of Bence-Jones proteins in diagnostic urine analysis?
(A) Diabetes mellitus
(B) Multiple myeloma
(C) Hepatic cirrhosis
(D) Acute pancreatitis

2023

42. Match the items in List I with those in List II and select the correct option:
List I: (Wildlife Pathobiochemistry)
P. Capture myopathy
Q. Stress response
R. Diabetes mellitus
S. Leukoencephalomyelopathy
List II: (Characteristic)
1. Cortisol elevation
2. Non-human primates
3. Cheetahs
4. Creatine kinase elevation
(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-4, S-1

2012

43. Which physiological fluid shift is a primary characteristic of acute stress and pursuit during wildlife capture?
(A) Hemoconcentration
(B) Hemodilution
(C) Hypovolemic alkalosis
(D) Isotonic expansion

2022

44. What is the fundamental mechanism driving the pathobiochemistry of diabetes mellitus commonly observed in captive non-human primates?
(A) Autoimmune destruction of alpha cells
(B) Excessive glucagon synthesis
(C) Insulin resistance linked to obesity
(D) Viral destruction of the pancreas

2002

45. In Phase I xenobiotic metabolism, which organelle predominantly houses the Cytochrome P450 enzyme complex?
(A) Outer mitochondrial membrane
(B) Acidic lysosomal compartments
(C) Luminal Golgi apparatus
(D) Smooth endoplasmic reticulum

2014

46. Glutathione conjugation during Phase II detoxification utilizes an enzyme that heavily relies on which specific functional group?
(A) Hydroxyl functional group
(B) Primary amino group
(C) Sulfhydryl group
(D) Carboxyl functional group

2007

47. Consider the following factors causing decreased hematocrit:
I. Anemia
II. Dehydration
III. Severe hemorrhage
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I

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2004

48. What is the consequence of a genetic deficiency in glucose-6-phosphate dehydrogenase (G6PD) in erythrocytes?
(A) Enhanced molecular oxygen binding
(B) Inability to synthesize cellular ATP
(C) Accelerated rate of glycolysis
(D) Increased oxidative hemolysis

2012

49. Which process refers to the rapid uptake of oxygen by macrophages to generate reactive oxygen species?
(A) Respiratory burst
(B) Phagocytosis
(C) Opsonization
(D) Chemotaxis

results.
Which of the above statements is/are correct?
(A) I and III
(B) I, II and III
(C) I and II
(D) II

2007

30. Which specific region of the nephron is responsible for the bulk reclamation of filtered bicarbonate?
(A) Loop of Henle
(B) Distal convoluted tubule
(C) Proximal convoluted tubule
(D) Collecting duct

2006

31. Consider the following statements regarding muscle biochemistry:
I. ATP is the immediate energy source for contraction.
II. Smooth muscle lacks actin and myosin filaments.
III. Creatine phosphate regenerates ATP during initial exertion.
IV. Cardiac muscle strictly relies on anaerobic glycolysis.
Which of the above statements is/are INCORRECT?
(A) I, II and III
(B) II and IV
(C) I and III
(D) I, III and IV

2005

32. Which macromolecule imparts significant compressive resilience and shock absorption properties to cartilage extracellular matrix?
(A) Elastin
(B) Fibronectin
(C) Type I collagen
(D) Proteoglycans

2001

33. Consider the following statements concerning bone tissue biochemistry:
I. Osteoid is primarily composed of Type I collagen.
II. Hydroxyapatite crystals contain calcium and phosphorus.
III. Osteoclasts are responsible for bone formation.
IV. Calcitonin stimulates bone resorption.
V. Acid phosphatase is an osteoclast marker.
Which of the above statements is/are correct?
(A) I, II and V
(B) I, II, III and V
(C) I, II, IV and V
(D) II, IV and V

2008

34. In brain energy metabolism, which alternative substrate can neurons efficiently utilize during prolonged periods of starvation?
(A) Free fatty acids
(B) Amino acids
(C) Ketone bodies
(D) Glycerol

2007

35. Select the correct order of enzymes involved in the primary lipolytic cascade in adipose tissue.
(A) ATGL, HSL, MGL
(B) HSL, ATGL, MGL
(C) MGL, HSL, ATGL
(D) ATGL, MGL, HSL

2016

36. Which precursor is essential for the biochemical synthesis of lactose within the alveolar cells of the mammary gland?
(A) Fructose
(B) Galactose
(C) Sucrose
(D) UDP-galactose

2004

37. Read the following assertion and reason and select the correct option:
Assertion (A): Chronic iodine deficiency in animals leads to thyroid gland hypertrophy (goiter).
Reason (R): Decreased thyroid hormone levels eliminate negative feedback, increasing TSH secretion.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

38. The physiological release of parathyroid hormone (PTH) is immediately triggered by which condition?
(A) Hypercalcemia
(B) Hypophosphatemia
(C) Hypocalcemia
(D) Hypermagnesemia

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2011

60. Intestinal absorption of iron is negatively regulated by which peptide hormone released by the liver?
(A) Erythropoietin
(B) Gastrin
(C) Hepcidin
(D) Cholecystokinin

2017

61. Calcitonin serves to lower circulating blood calcium levels primarily by inhibiting the functional activity of which cells?
(A) Enterocytes
(B) Osteoblasts
(C) Renal tubular cells
(D) Osteoclasts

2012

62. Select the correct order of relative tissue specificity for diagnostic enzymes indicating hepatic damage in small animals, from most to least specific.
(A) ALT, AST, ALP
(B) AST, ALT, ALP
(C) ALP, ALT, AST
(D) ALT, ALP, AST

2019

63. A marked decrease in glomerular filtration rate (GFR) invariably manifests primarily as an elevation of which parameter?
(A) Urine specific gravity
(B) Serum creatinine
(C) Serum albumin
(D) Urine glucose

2005

64. The qualitative detection of glycosuria in a routine animal urinalysis is most commonly associated with which underlying defect?
(A) Glomerular basement membrane rupture or leak
(B) Defective collecting duct aquaporin channels
(C) Insufficient dietary carbohydrate intake
(D) Exceeding the renal glucose threshold

2010

65. The distinct baseline hematological variations observed between wild herbivores and carnivores largely reflect adaptive differences in what?
(A) Nutritional metabolic pathways
(B) Reproductive cycles
(C) Fur insulation
(D) Bone density

2013

66. Elevated circulating cortisol in trapped wild populations is an established systemic biomarker for which physiological state?
(A) Capture myopathy
(B) Nutritional deficiency
(C) Acute physiological stress
(D) Chronic kidney disease

2002

67. Arrange the sequence of events leading to leukoencephalomyelopathy in captive cheetahs:
I. Demyelination in the spinal cord
II. Unknown genetic/nutritional trigger
III. Progressive ataxia and paresis
IV. Glial cell activation and neuroinflammation
(A) II, IV, I, III
(B) I, II, III, IV
(C) II, I, IV, III
(D) IV, II, I, III

2016

68. Which class of Phase I xenobiotic reactions typically requires molecular oxygen and NADPH?
(A) Hydrolysis
(B) Reduction
(C) Hydration
(D) Oxidation

2007

69. Sulfation in Phase II xenobiotic detoxification primarily utilizes which active donor molecule?
(A) S-adenosylmethionine (active methyl)
(B) PAPS (active sulfate donor molecule)
(C) Acetyl-CoA (active acetyl group)
(D) UDP-glucuronic acid (active sugar)

2011

70. Estimation of total blood volume using the dilution principle commonly requires administration of a known quantity of which substance?
(A) Radioactive iodine
(B) Fluorescein
(C) Evans Blue or T-1824
(D) Methylene blue

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2001

71. Glycolysis in mammalian erythrocytes operates purely anaerobically due to the complete absence of which cellular organelle?
(A) Nucleus
(B) Ribosomes
(C) Endoplasmic reticulum
(D) Mitochondria

298. (B) Induce rapid luteolysis of a mature corpus luteum

Prostaglandin F_2-alpha is commonly used in veterinary medicine to synchronize estrus in cattle by inducing the rapid regression, or luteolysis, of a mature corpus luteum. When the CL regresses, the source of progesterone is removed, allowing the animal to return to estrus within a few days. This allows producers to coordinate the breeding of large groups of animals, improving the efficiency of artificial insemination programs and management of the reproductive cycles within a herd.

299. (A) Preovulatory surge of GnRH and LH

During the luteal phase of the estrous cycle, high levels of progesterone exert a strong negative feedback effect on the hypothalamus and pituitary. This specifically prevents the preovulatory surge of GnRH and LH, thereby ensuring that no new ovulations occur while a corpus luteum is present or during pregnancy. This regulatory mechanism is essential for maintaining the stability of the reproductive cycle and protecting the developing fetus by preventing the onset of a new estrous cycle.

300. (B) Progesterone

Progesterone is a key biochemical marker measured in the milk or blood of dairy cattle approximately 21 days after mating to confirm the presence of a functional corpus luteum. A high level of progesterone at this time indicates that the animal has not returned to estrus and is potentially pregnant. Conversely, low levels suggest that the corpus luteum has regressed and the cow is starting a new cycle, allowing for the early identification and re-breeding of non-pregnant animals to maintain herd productivity.

****

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II. Milk lipids form true emulsions.
III. Lactose synthesis occurs in the rough endoplasmic reticulum.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I

2013

83. Excess intracellular iron is sequestered and safely stored in tissues primarily in the form of which complex?
(A) Ferritin
(B) Haptoglobin
(C) Transferrin
(D) Hemopexin

2022

84. Which clinical sign is an immediate pathobiochemical manifestation of acute, severe hypocalcemia in lactating dairy cows?
(A) Severe tetanic muscle spasms
(B) Multiple severe bone fractures
(C) Formation of renal calculi
(D) Flaccid paralysis (milk fever)

2015

85. Significant elevation in the hepatic enzyme Gamma-Glutamyl Transferase (GGT) is most indicative of which pathology?
(A) Hepatocellular necrosis
(B) Cholestasis (biliary stasis)
(C) Hepatic lipidosis
(D) Portal vein thrombosis

2021

86. Which endogenous substance is continuously produced and freely filtered, making it the most practical standard for clinical GFR estimation?
(A) Urea
(B) Glucose
(C) Creatinine
(D) Uric acid

2014

87. Consider the following statements regarding routine urine biochemistry:
I. Normal urine specific gravity indicates concentrating ability.
II. Pathological proteinuria typically indicates glomerular damage.
III. Ketonuria is normal in well-fed non-ruminants.
IV. Glycosuria always implies diabetes mellitus.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) I, II and III
(C) III and IV
(D) II, III and IV

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2011

88. Variations in wild animal baseline hematology must primarily be interpreted relative to what contextual factor?
(A) Capture method and sedation protocols
(B) The phase of the moon
(C) Standard reference ranges of domestic species
(D) Coat color phenotypes

2002

89. Capture myopathy in wildlife is biochemically driven by extreme exertion leading to massive cellular accumulation of what?
(A) Uric acid
(B) Lactic acid
(C) Urea
(D) Bicarbonate

2012

90. Diabetes mellitus in captive non-human primates closely mimics which human condition biochemically?
(A) Type 1 Diabetes
(B) Type 2 Diabetes
(C) Gestational Diabetes
(D) Diabetes Insipidus

2015

91. Cytochrome P450 enzymes typically catalyze the insertion of one oxygen atom into the substrate and the other into what molecule?
(A) Water
(B) Carbon dioxide
(C) Hydrogen peroxide
(D) Urea

2010

92. Consider the following Phase II xenobiotic detoxification pathways:
I. Glucuronidation
II. Sulfation
III. Hydrolysis
IV. Glutathione conjugation
V. Oxidation
Which of the above statements is/are correct?
(A) I, II, III and V
(B) I, II and IV
(C) II, III, IV and V
(D) I, IV and V

2025

162. Which coenzyme serves as the essential electron donor for the Cytochrome P450 monooxygenase system in the liver?
(A) NADH
(B) FADH2
(C) NADPH
(D) Coenzyme A

2018

163. The tripeptide glutathione, vital for Phase II conjugation and cellular protection, is composed of glutamate, glycine, and which other amino acid?
(A) Cysteine
(B) Methionine
(C) Serine
(D) Alanine

2002

164. In standard veterinary hematology, the buffy coat comprises which two cellular components?
(A) Erythrocytes and platelets
(B) Reticulocytes and leukocytes
(C) Plasma and erythrocytes
(D) Leukocytes and platelets

2006

165. Which erythrocyte enzyme converts methemoglobin ($Fe^{\{3+\}}$) back to functional hemoglobin ($Fe^{\{2+\}}$) using NADH?
(A) Superoxide dismutase
(B) Cytochrome b5 reductase
(C) Glutathione peroxidase
(D) Catalase

2014

166. Nitric oxide (NO), a critical signaling molecule released by activated macrophages, is synthesized directly from which amino acid?
(A) Citrulline
(B) Ornithine
(C) Arginine
(D) Glutamate

2017

167. Albumin maintains plasma oncotic pressure primarily because of its high concentration and what other physical property?
(A) High molecular weight
(B) Highly hydrophobic surface
(C) Positive net charge at pH 7.4
(D) Low molecular weight

2009

168. Fetal hemoglobin's higher oxygen affinity facilitates which critical physiological process?
(A) Oxygen transfer across the placenta
(B) Rapid oxygen offloading in fetal tissues
(C) Constant buffering of fetal blood pH
(D) Systemic resistance to carbon monoxide

2009

169. According to the Henderson-Hasselbalch equation, if the blood pH equals the pKa of the buffer system, the ratio of base to acid must be:
(A) 10 to 1
(B) 1 to 1
(C) 1 to 10
(D) Zero

2013

170. Which specific cell type in the collecting duct is primarily responsible for the active secretion of protons in the final adjustment of urine pH?
(A) Principal cells
(B) Type A intercalated cells
(C) Type B intercalated cells
(D) Macula densa cells

2010

171. The regeneration of ATP via the creatine phosphate system in muscle is characterized by which reaction kinetic profile?
(A) Very rapid, very limited capacity
(B) Extremely slow, sustained capacity
(C) Moderately fast, high capacity
(D) Very slow, limited capacity

2004

172. The tensile strength of collagen fibers fundamentally originates from which secondary structure characteristic?
(A) Alpha helix
(B) Beta pleated sheet
(C) Triple helix
(D) Random coil

2024

173. The organic matrix of bone (osteoid) is distinguished from other connective tissues primarily by its capacity to undergo what?
(A) High rate of rapid turnover
(B) Dynamic property of elastic recoil
(C) Cellular process of phagocytosis
(D) Extensive calcification

2008

174. Which biochemical pathway ensures the prompt clearance and recycling of the neurotransmitter glutamate from the synaptic cleft?
(A) Degradation by monoamine oxidase enzymes
(B) Hydrolysis by acetylcholinesterase enzyme

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(PINP)
(D) C-terminal telopeptide (CTX)

2006

104. Which vital neurotransmitter is uniquely synthesized in the presynaptic terminal by choline acetyltransferase?
(A) Acetylcholine
(B) Dopamine
(C) Serotonin
(D) Glutamate

2018

105. During fasting, lipolysis in adipose tissue is predominantly stimulated by an increase in which intracellular messenger?
(A) cGMP
(B) cAMP
(C) Calcium
(D) IP3

2014

106. In milk protein synthesis, which structural form does casein predominantly assume to stably transport large amounts of calcium phosphate?
(A) Fibrils
(B) Micelles
(C) Globules
(D) Helices

2005

107. Read the following assertion and reason and select the correct option:
Assertion (A): Iodine toxicity is relatively rare in most livestock species compared to deficiency.
Reason (R): The mammalian kidney can rapidly excrete excess dietary iodide.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

108. Severe hypophosphatemia in animals primarily impairs cellular function by restricting the production of what?
(A) Triglycerides
(B) Glycogen
(C) ATP
(D) Cholesterol

2012

109. An elevation in unconjugated (indirect) bilirubin in the blood is most highly suggestive of which pathological process?
(A) Biliary tract obstruction
(B) Hepating cirrhosis
(C) Pancreatic insufficiency
(D) Excessive erythrocyte hemolysis

2016

110. The measurement of which non-protein nitrogen compound evaluates renal function but is highly dependent on hepatic synthesis capacity?
(A) Systemic uric acid
(B) Circulating ammonia
(C) Urea nitrogen (BUN)
(D) Muscle creatinine

2017

111. Proteinuria is considered a significant pathological finding if the proteins present are predominantly composed of what?
(A) Tamm-Horsfall proteins
(B) Albumin
(C) Immunoglobulin light chains
(D) Glycoproteins

2001

112. Match the items in List I with those in List II and select the correct option:
List I: (Clinical Enzymology)
P. ALT
Q. GGT
R. Creatine Kinase
S. Amylase
List II: (Indication)
1. Muscle damage
2. Hepatic necrosis
3. Pancreatitis
4. Cholestasis
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

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2004

113. Species-specific blood typing in wildlife is critical prior to transfusion primarily to prevent which fatal complication?
(A) Acute hemolytic reaction
(B) Septic shock
(C) Pulmonary edema
(D) Hemorrhagic diathesis

2013

138. The biochemical profile of a non-human primate with diabetes mellitus typically shows chronic hyperglycemia alongside elevated what?
(A) Ketone body clearance
(B) Insulin levels (initially)
(C) High-density lipoproteins
(D) Calcium absorption

2019

139. Phase I metabolic reactions primarily serve to prepare xenobiotics for Phase II by achieving what chemical objective?
(A) Introducing a polar functional group
(B) Increasing total lipid solubility
(C) Polymerizing the target toxin
(D) Binding the toxin to albumin

2023

140. Glucuronidation significantly enhances the renal excretion of toxic metabolites by increasing their what?
(A) Lipid partition coefficient
(B) Molecular stability
(C) Water solubility
(D) Volatility

2011

141. The estimation of total blood volume using isotope dilution commonly employs red blood cells tagged with which radioisotope?
(A) Iodine-131
(B) Carbon-14
(C) Tritium
(D) Chromium-51

2010

142. If the Hexose Monophosphate (HMP) pathway fails, oxidized hemoglobin precipitates in erythrocytes, forming what distinct structures?
(A) Howell-Jolly bodies
(B) Basophilic stippling
(C) Heinz bodies
(D) Cabot rings

2006

143. Platelet dense granules play a pivotal role in the amplification of platelet activation by releasing high concentrations of what?
(A) Fibrinogen
(B) ADP and Serotonin
(C) Thromboxane A_2
(D) Plasminogen

2004

144. Which technique applies an electrical field to precisely separate plasma proteins based on their net charge and mass?
(A) Ultracentrifugation
(B) Gel filtration chromatography
(C) Mass spectrometry
(D) Electrophoresis

2014

145. Carbon monoxide is exceptionally lethal because it binds hemoglobin with an affinity approximately how many times greater than oxygen?
(A) 2 times
(B) 20 times
(C) 250 times
(D) 1000 times

2006

146. In the bicarbonate buffering system, the physiological concentration of dissolved carbon dioxide is directly proportional to what?
(A) Total alveolar ventilation rate
(B) Rate of renal bicarbonate excretion
(C) Partial pressure of CO_2 (pCO_2)
(D) Serum sodium cation concentration

2005

147. To achieve maximum urinary acidification and titratable acidity, the renal tubules rely heavily on buffering by which system?
(A) Phosphate
(B) Bicarbonate
(C) Ammonia
(D) Proteins

2011

148. Cardiac muscle tissue uniquely possesses a high concentration of which organelle to sustain its immense aerobic energy requirements?
(A) Sarcoplasmic reticulum
(B) Golgi apparatus
(C) Lysosomes
(D) Mitochondria

2021

149. The structural integrity and maturation of collagen fibers are completely dependent on the hydroxylation of proline and lysine, a reaction requiring what?
(A) Vitamin A
(B) Vitamin C
(C) Vitamin D
(D) Vitamin K

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2001

126. Proteoglycans consist of a core protein covalently attached to long, unbranched polysaccharides known collectively as what?
(A) Complex cellular glycogens
(B) Cell-bound glycosphingolipids
(C) Glycosaminoglycans (GAGs)
(D) Bacterial peptidoglycans

2022

127. Which systemic hormone directly stimulates osteoblasts to synthesize osteoid matrix and coordinates subsequent bone mineralization?
(A) Cortisol
(B) Growth hormone
(C) Parathyroid hormone
(D) Calcitonin

2015

128. Brain energy metabolism normally demonstrates an absolute, continuous physiological dependency on the steady supply of which nutrient?
(A) Fatty acids
(B) Amino acids
(C) Fructose
(D) Glucose

2006

129. Thermogenin (UCP-1) in brown adipose tissue generates heat by uncoupling oxidative phosphorylation from the synthesis of what?
(A) ATP
(B) NADH
(C) Carbon dioxide
(D) Water

2002

130. Hormonal induction of lactogenesis in the mammary gland is critically dependent on the precipitous periparturient drop of which hormone?
(A) Prolactin
(B) Estrogen
(C) Progesterone
(D) Growth hormone

2009

131. Toxic accumulation of dietary iron, leading to organ damage (hemochromatosis), primarily disrupts cellular integrity through what mechanism?
(A) Generation of free radicals
(B) Direct inhibition of ATP synthase
(C) Massive precipitation of transferrin
(D) Competitive blockade of calcium channels

2023

132. Phosphorus homeostasis is intricately linked with calcium; which hormone potently promotes renal phosphate excretion?
(A) Calcitriol
(B) Calcitonin
(C) Aldosterone
(D) Parathyroid hormone (PTH)

2002

133. Elevations in serum Alanine Aminotransferase (ALT) are highly liver-specific in dogs and cats, but poor indicators of hepatic disease in which species?
(A) Non-human primates
(B) Horses and ruminants
(C) Rats
(D) Swine

2014

134. Glomerular filtration rate (GFR) can be precisely determined by calculating the renal clearance of which exogenously administered carbohydrate?
(A) Glucose
(B) Dextran
(C) Inulin
(D) Fructose

2014

135. Physiological variations in urine pH strongly correlate with diet; strict carnivore diets generally result in urine that is what?
(A) Highly alkaline
(B) Neutral
(C) Extremely dilute
(D) Mildly acidic

2015

136. Normal physiological fluid shifts in wildlife under stress commonly involve the contraction of which specific compartment?
(A) Plasma volume
(B) Intracellular fluid
(C) Interstitial fluid
(D) Transcellular fluid

2014

137. Which clinical manifestation is definitively indicative of advanced capture myopathy in wild ungulates?
(A) Profuse watery diarrhea
(B) Myoglobinuria (dark brown urine)
(C) Sustained bradycardia
(D) Severe systemic hypothermia

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2023

114. Elevated cortisol indicating stress in wild populations can induce prolonged immunosuppression by causing apoptosis in which cell line?
(A) Erythrocytes
(B) Macrophages
(C) Lymphocytes
(D) Platelets

2009

115. A fundamental biochemical feature of leukoencephalomyelopathy in cheetahs is the progressive degeneration of what structure?
(A) Myelin sheaths
(B) Motor neuron cell bodies
(C) Peripheral neuromuscular junctions
(D) Cerebellar Purkinje cells

2004

116. Which reaction mechanism is LEAST likely to be mediated by the Phase I Cytochrome P450 monooxygenase system?
(A) N-dealkylation
(B) Aromatic hydroxylation
(C) Epoxidation
(D) Peptide bond hydrolysis

2010

117. Biliary excretion is a primary route for eliminating xenobiotic metabolites that have which physical characteristic?
(A) State of high volatility
(B) High molecular weight
(C) Low molecular weight mass
(D) Extreme lipid solubility

2017

118. Which hematological index mathematically calculates the average volume of a single circulating erythrocyte?
(A) MCHC
(B) MCH
(C) MCV
(D) RDW

2022

119. The Rapoport-Luebering shunt requires the specialized catalytic action of which enzyme exclusive to erythrocytes?
(A) Phosphofructokinase
(B) Pyruvate kinase
(C) Lactate dehydrogenase
(D) Bisphosphoglycerate mutase

2007

120. Macrophage phagolysosome formation facilitates pathogen destruction by merging engulfed particles directly with what?
(A) Lysosomal hydrolytic enzymes
(B) Mitochondria
(C) Nuclei
(D) Rough endoplasmic reticulum

NODIA

2023

121. The A:G ratio is most commonly inverted (globulins exceeding albumin) in which of the following chronic veterinary conditions?
(A) Malnutrition
(B) Chronic systemic infection
(C) Protein-losing enteropathy
(D) Acute blood loss

2007

122. Under conditions of high tissue carbon dioxide levels, hemoglobin undergoes a conformational shift favoring which structural state?
(A) R-state (relaxed)
(B) T-state (tense)
(C) Methemoglobin state
(D) Carboxyhemoglobin state

2015

123. The Henderson-Hasselbalch equation defines the relationship wherein a buffer operates optimally when the pH is equal to what?
(A) The negative logarithm of K_a (pKa)
(B) The acid dissociation constant (K_a)
(C) The total concentration of the base
(D) The value of 7.4 exactly

2025

124. Renal bicarbonate reclamation fundamentally depends on the secretion of protons into the tubular lumen via which mechanism?
(A) H+/K^+ ATPase
(B) H+ uniporter
(C) Na^+/H+ antiporter
(D) Na^+/K^+ ATPase

2010

125. The high-energy demands of smooth muscle tissue during sustained, tonic contractions are met predominantly through which pathway?
(A) Creatine phosphate system
(B) Anaerobic glycolysis
(C) Adenylate kinase reaction
(D) Aerobic oxidative phosphorylation

2003

150. Osteoclast-mediated bone resorption requires the localized secretion of which substance to dissolve hydroxyapatite crystals?
(A) Collagenase
(B) Bicarbonate
(C) Hydrochloric acid
(D) Citric acid

2006

151. Which specialized class of lipids, highly enriched in the brain, features complex oligosaccharide chains ending in sialic acid?
(A) Plasmalogens
(B) Phosphatidylcholines
(C) Ceramides
(D) Gangliosides

2011

152. Insulin powerfully suppresses lipolysis in white adipose tissue by activating an enzyme that directly degrades what?
(A) cAMP
(B) cGMP
(C) ATP
(D) AMP

2023

153. Within the mammary gland, the final assembly of milk lipids into fat globules involves envelopment by what cellular structure?
(A) Endoplasmic reticulum membrane
(B) Apical plasma membrane
(C) Golgi membrane
(D) Nuclear envelope

2021

154. Clinical manifestations of iron deficiency in domestic mammals most notably include the development of what hematological condition?
(A) Macrocytic normochromic anemia
(B) Microcytic hypochromic anemia
(C) Hemolytic anemia
(D) Aplastic anemia

2021

155. The activation of Vitamin D to its most potent hormonal form, calcitriol (1,25-dihydroxycholecalciferol), is completed in which organ?
(A) Kidney
(B) Skin
(C) Liver
(D) Intestine

2005

156. An increased unconjugated bilirubin combined with normal hepatic enzyme activities strongly indicates which physiological process?
(A) Complete biliary tract obstruction
(B) Advanced hepatocellular carcinoma
(C) Extravascular or intravascular hemolysis
(D) Case of acute clinical hepatitis

2017

157. Accurate calculation of the Glomerular Filtration Rate (GFR) mathematically requires the urine concentration of the marker, the serum concentration, and what else?
(A) Patient's body weight
(B) Patient's age
(C) Blood pressure
(D) Urine flow rate

2011

158. Qualitative analysis of normal mammalian urine typically reveals it to be chemically devoid of significant quantities of which substance?
(A) Urea
(B) Creatinine
(C) Glucose
(D) Uric acid

2002

159. Physiological stress from pursuit in wild ungulates causes splenic contraction, leading immediately to an artifactual increase in what?
(A) Plasma volume
(B) Hematocrit
(C) Leukocyte count
(D) Platelet aggregation

2016

160. Measurement of which specific enzyme isoform provides the most definitive confirmation of skeletal muscle damage in capture myopathy?
(A) CK-MB
(B) CK-BB
(C) AST
(D) CK-MM

2012

161. The pathophysiology of non-human primate diabetes typically culminates in hyperosmolar hyperglycemic state rather than what?
(A) Diabetic ketoacidosis
(B) Renal failure
(C) Cataracts
(D) Peripheral neuropathy

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(C) Methylation
(D) Amino acid conjugation

2022

187. The estimation of total blood volume using plasma volume and hematocrit relies on which fundamental mathematical assumption?
(A) $\text{Total Blood Volume} = \frac{\text{Plasma Volume}}{1 - \text{Hematocrit}}$
(B) $\text{Total Blood Volume} = \text{Plasma Volume} \times \text{Hematocrit}$
(C) $\text{Total Blood Volume} = \text{Plasma Volume} + \text{Hematocrit}$
(D) $\text{Total Blood Volume} = \frac{\text{Plasma Volume}}{\text{Hematocrit}}$

2013

188. In the erythrocyte glycolytic pathway, the conversion of 1,3-bisphosphoglycerate to 3-phosphoglycerate is essential for the production of what?
(A) NADH
(B) Pyruvate
(C) ATP
(D) Lactate

2004

189. Which structural component of the platelet undergoes dramatic reorganization during the activation and shape-change phase?
(A) Nuclear envelope
(B) Endoplasmic reticulum
(C) Mitochondria
(D) Actin cytoskeleton

2017

190. Fibrinogen, a massive glycoprotein essential for hemostasis, is exclusively synthesized by which organ?
(A) Kidney
(B) Bone marrow
(C) Liver
(D) Spleen

2008

191. The oxygen dissociation curve of hemoglobin is sigmoidal in shape due to which fundamental biochemical principle?
(A) Competitive inhibition
(B) Cooperative binding
(C) Non-competitive inhibition
(D) Covalent modification

2025

192. During intense physical exertion, the blood pH decreases slightly; how does this benefit actively respiring tissues?
(A) Increasing hemoglobin affinity to hoard oxygen
(B) Denaturing plasma proteins for amino acid use
(C) Accelerating carbon dioxide binding to heme
(D) Decreasing oxygen affinity to enhance release

NODIA

2009

193. The synthesis of new bicarbonate ions in the renal tubules relies fundamentally on the intracellular activity of which ubiquitous enzyme?
(A) Carbonic anhydrase
(B) Urease
(C) Glutaminase
(D) Hexokinase

2011

194. Which characteristic strictly distinguishes the biochemistry of smooth muscle contraction from that of striated muscle?
(A) Absolute dependence on calcium ions
(B) Metabolic requirement of ATP hydrolysis
(C) Myosin light chain phosphorylation
(D) Interaction between actin and myosin units

2008

195. Proteoglycans impart extraordinary resistance to tissue compression primarily because their glycosaminoglycan chains strongly attract what?
(A) Water
(B) Lipids
(C) Calcium
(D) Collagen

2014

196. The systemic marker Osteocalcin requires post-translational carboxylation to bind bone calcium efficiently; this modification strictly depends on which vitamin?
(A) Vitamin A
(B) Vitamin C
(C) Vitamin D
(D) Vitamin K

2007

197. Cerebrosides and gangliosides in nerve tissue are synthesized from ceramide primarily within which cellular organelle?
(A) Mitochondria
(B) Golgi apparatus
(C) Lysosomes
(D) Nucleus

2025

198. During extreme cold stress, brown adipose tissue thermogenesis is centrally stimulated by the release of which neurotransmitter?

(C) Astrocyte uptake and glutamine conversion
(D) Direct diffusion into the bloodstream flow

2023

175. The specific thermogenic property of brown adipose tissue is physiologically most crucial for which group of animals?
(A) Mature adult ruminant species
(B) Neonatal and hibernating mammals
(C) Tropical avian bird species
(D) Mature mammalian carnivores

2019

176. Lactose synthase, the enzyme responsible for lactose production in the mammary gland, requires the regulatory presence of which milk protein?
(A) Beta-lactoglobulin
(B) Kappa-casein
(C) Lactoferrin
(D) Alpha-lactalbumin

2001

177. The majority of circulating iodine in mammals is actively sequestered by which endocrine organ?
(A) Thyroid gland
(B) Pancreas
(C) Adrenal gland
(D) Pituitary gland

2002

178. Parathyroid hormone (PTH) acts on the distal convoluted tubule of the kidney to heavily promote the reabsorption of what?
(A) Sodium
(B) Phosphorus
(C) Calcium
(D) Potassium

2009

179. In ruminants and horses, which hepatic enzyme is considered the most sensitive and specific biomarker for hepatocellular injury?
(A) SDH (Sorbitol Dehydrogenase)
(B) ALT (Alanine Aminotransferase)
(C) AST (Aspartate Aminotransferase)
(D) ALP (Alkaline Phosphatase)

2016

180. A disproportionate elevation of BUN compared to serum creatinine is most frequently indicative of which specific condition?
(A) Acute renal tubular necrosis pathology
(B) Post-renal urinary tract obstruction
(C) Chronic glomerular disease states
(D) Pre-renal azotemia

2002

181. Heavy proteinuria accompanied by severe hypoalbuminemia, edema, and hypercholesterolemia constitutes the classic diagnostic triad for what?
(A) Nephrotic syndrome
(B) Diabetes insipidus
(C) Fanconi syndrome
(D) Pyelonephritis

2021

182. A major physiological obstacle in establishing universal baseline blood biochemistry parameters for wildlife is the profound effect of what?
(A) Atmospheric pressure variations
(B) Seasonal coat shedding
(C) Chemical immobilization and physical restraint
(D) Genetic monomorphism

2015

183. The extreme rhabdomyolysis characterizing wildlife capture myopathy invariably floods the systemic circulation with which nephrotoxic protein?
(A) Hemoglobin
(B) Fibrinogen
(C) Albumin
(D) Myoglobin

2015

184. Non-human primate models of diabetes mellitus frequently demonstrate significant amyloid deposition within which specific anatomical structures?
(A) Pancreatic islets of Langerhans
(B) Renal glomeruli filtration units
(C) Hepatic sinusoids of the liver
(D) Cerebral cortex of the brain

2006

185. Cytochrome P450 isoenzymes exhibit distinct substrate specificities; however, their expression in the liver can be powerfully altered by what?
(A) Transient blood pH level fluctuations
(B) Induction by repetitive xenobiotic exposure
(C) Clinical states of mild hypothermia
(D) Long-term high carbohydrate diet intake

2019

186. Which phase II xenobiotic reaction is universally critical for the detoxification of reactive oxygen species and electrophilic intermediate metabolites?
(A) Acetylation
(B) Glutathione conjugation

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2018

93. In domestic animals, severe dehydration directly leads to a relative increase in which hematological index?
(A) Mean corpuscular hemoglobin
(B) Reticulocyte count
(C) Total leukocyte count
(D) Hematocrit

2025

94. The continuous function of the Hexose Monophosphate (HMP) pathway is completely dependent on the availability of which substrate?
(A) NAD+
(B) Pyruvate
(C) Glucose-6-phosphate
(D) Fructose-1,6-bisphosphate

2011

95. Platelet activation cascades often involve the hydrolysis of membrane phospholipids to release which critical secondary messenger precursor?
(A) Inositol triphosphate (IP3)
(B) Arachidonic acid
(C) Cyclic AMP
(D) Calcium

2010

96. Which electrophoretic plasma fraction contains circulating antibodies critical for humoral immune defense?
(A) Alpha-1 globulin
(B) Alpha-2 globulin
(C) Beta globulin
(D) Gamma globulin

2005

97. Read the following assertion and reason and select the correct option:
Assertion (A): Fetal hemoglobin typically possesses a higher affinity for oxygen than adult hemoglobin.
Reason (R): Fetal hemoglobin binds 2,3-BPG more weakly than adult hemoglobin.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

98. Which acid-base disorder is most likely characterized by low blood pH and high partial pressure of carbon dioxide?
(A) Metabolic acidosis
(B) Metabolic alkalosis
(C) Respiratory acidosis
(D) Respiratory alkalosis

2011

99. The measurement of titratable acidity in urine primarily quantifies protons buffered by which molecular species?
(A) Phosphate
(B) Ammonia
(C) Bicarbonate
(D) Creatinine

2015

100. Smooth muscle contraction differs biochemically from skeletal muscle due to its reliance on which regulatory protein instead of troponin?
(A) Tropomyosin
(B) Actin
(C) Myosin light-chain kinase
(D) Calmodulin

NODIA

2007

101. What is the primary functional significance of the extensive cross-linking observed in collagen extracellular matrix fibers?
(A) Increasing hydration and gel formation
(B) Providing high tensile strength
(C) Allowing enzymatic degradation
(D) Facilitating cell division

2019

102. Match the items in List I with those in List II and select the correct option:
List I: (Biochemical Processes)
P. Glycolysis
Q. Gluconeogenesis
R. Lipolysis
S. Lipogenesis
List II: (Definition)
1. Breakdown of triglycerides
2. Synthesis of fatty acids
3. Conversion of glucose to pyruvate
4. Synthesis of glucose from lactate
(A) P-2, Q-4, R-1, S-3
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

2004

103. Which systemic biochemical marker is most commonly assayed in blood to assess active bone resorption by osteoclasts?
(A) Alkaline phosphatase
(B) Osteocalcin
(C) Procollagen type I N-terminal propeptide

(A) Acetylcholine
(B) Serotonin
(C) Norepinephrine
(D) Dopamine

2014

199. Milk lipid synthesis is uniquely characterized by the mammary gland's ability to synthesize medium-chain fatty acids utilizing a specialized enzyme called what?
(A) Acetyl-CoA carboxylase
(B) Lipoprotein lipase
(C) Hormone-sensitive lipase
(D) Thioesterase II

2016

200. The regulatory hormone hepcidin induces the internalization and degradation of which essential iron export protein on the enterocyte basolateral membrane?
(A) Ferroportin
(B) Transferrin receptor
(C) Ferritin
(D) DMT-1

2024

201. Calcitonin exerts its rapid hypocalcemic effect primarily through direct biochemical interaction with receptors located on which cells?
(A) Osteoblasts
(B) Osteoclasts
(C) Thyroid parafollicular cells
(D) Enterocytes

2005

202. Serum Alkaline Phosphatase (ALP) levels are frequently physiologically elevated in growing young animals due to what process?
(A) Immature hepatic clearance
(B) Active bone remodeling and growth
(C) High dietary fat intake
(D) Rapid muscle development

2006

203. Which clearance test mathematically estimates the true Glomerular Filtration Rate (GFR) but requires continuous intravenous infusion?
(A) Inulin clearance
(B) Creatinine clearance
(C) Urea clearance
(D) PAH clearance

2004

204. Normal ruminant urine is typically alkaline and rich in which specific compound, reflecting their unique nitrogen metabolism?
(A) Uric acid
(B) Allantoin
(C) Urea
(D) Creatine

2015

205. The prominent presence of nucleated erythrocytes in healthy adult avian and reptilian blood distinctly contrasts with standard mammalian what?
(A) Hemoglobin structure
(B) Platelet function
(C) Leukocyte differentiation
(D) Erythrocyte morphology

2011

206. Capture myopathy is characterized by severe metabolic acidosis resulting from the massive systemic release of what?
(A) Ketone bodies from lipolysis
(B) Uric acid from purine breakdown
(C) Lactic acid from anaerobic glycolysis
(D) Hydrochloric acid from the stomach

2024

207. Which progressive central nervous system disorder in cheetahs results in distinct pathobiochemical demyelination in the spinal cord?
(A) Rabies
(B) Leukoencephalomyelopathy
(C) Canine distemper
(D) Spongiform encephalopathy

2001

208. The most functionally diverse and critical family of enzymes driving Phase I xenobiotic oxidation is definitively identified as what?
(A) Flavin-containing monooxygenases (FMOs)
(B) Alcohol dehydrogenases
(C) Monoamine oxidases
(D) Cytochrome P450 (CYP) superfamily

2004

209. Renal excretion of most xenobiotic metabolites depends on their Phase II conversion into molecules that are sufficiently what?
(A) Hydrophilic to prevent tubular reabsorption
(B) Hydrophobic to cross cell membranes
(C) Volatile to be expelled via lungs
(D) Insoluble to precipitate in urine

2008

210. Under physiological conditions, which hematological index mathematically describes the average hemoglobin concentration within a given volume of packed red blood cells?

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ANSWERS

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1. (A) Hematocrit
Hematocrit represents the percentage of whole blood that consists of red blood cells. It provides a direct measurement of the erythrocyte volume relative to the total blood volume. This parameter is essential for diagnosing anemia or polycythemia in domestic animals. It is determined by centrifuging a blood sample to separate cells from plasma.

2. (B) Both A and R are true but R is not the correct explanation of A.
The Rapoport-Luebering shunt allows erythrocytes to produce 2,3-bisphosphoglycerate by bypassing the phosphoglycerate kinase reaction. While this process sacrifices ATP production, it generates a critical allosteric regulator. 2,3-BPG decreases hemoglobin oxygen affinity, promoting oxygen release. Although both physiological facts are accurate, the shunt's bypass mechanism is defined by its metabolic path, not the BPG's function.

3. (A) NADPH oxidase
The respiratory burst is a rapid metabolic process in activated leukocytes designed to destroy pathogens. The enzyme NADPH oxidase initiates this sequence by transferring electrons from NADPH to molecular oxygen. This specific reaction results in the formation of superoxide anions. These anions serve as the precursors for other reactive oxygen species, including hydrogen peroxide and hypochlorous acid.

4. (D) Albumin
During serum protein electrophoresis at a physiological pH, proteins migrate toward the positive electrode based on their net negative charge and molecular size. Albumin possesses the highest net negative charge and the smallest molecular weight among the major plasma proteins. Consequently, it migrates the fastest and is found closest to the anode at the end of the separation process.

5. (B) Release of carbon dioxide from hemoglobin
The Haldane effect describes the property of hemoglobin where the binding of oxygen displaces carbon dioxide. In the lungs, the high partial pressure of oxygen promotes hemoglobin oxygenation. This conformational change reduces hemoglobin's affinity for carbon dioxide and protons. As a result, carbon dioxide is released from the hemoglobin molecule into the alveoli for exhalation during the respiratory process.

6. (A) I and II
Physiological buffering systems are essential for maintaining the narrow pH range required for life. Bicarbonate is the most important extracellular buffer, while phosphate functions primarily within the intracellular fluid and renal tubules. Although proteins are effective buffers at physiological pH due to their amino acid side chains, the statement claiming they are ineffective is incorrect, leaving the other two accurate.

7. (A) P-3, Q-2, R-1, S-4
Renal acid-base balance involves several distinct mechanisms for maintaining physiological pH. Bicarbonate reclamation occurs in the tubules to preserve filtered buffers. Titratable acidity specifically refers to the excretion of dihydrogen phosphate. Ammonium excretion involves generating new bicarbonate via glutamine metabolism. Carbonic anhydrase serves as the essential catalyst for the hydration of carbon dioxide, supporting these vital ion exchange processes.

8. (A) Liver
The Cori cycle is a metabolic pathway that coordinates energy production between skeletal muscle and the liver. During intense exercise, muscle cells produce lactate through anaerobic glycolysis. This lactate is released into the bloodstream and transported to the liver. The liver then converts lactate back into glucose through gluconeogenesis, which can be returned to the muscle for further energy.

9. (B) Glycine
Collagen molecules are characterized by a unique triple helical structure. This configuration requires a very small amino acid to fit within the restricted space where the three polypeptide chains come together. Glycine, being the smallest

2010

222. Caseins in milk precipitate readily in the stomach of the neonate due to the action of chymosin (rennin) and the acidic environment, facilitating what?
(A) Rapid gastric emptying process
(B) Immediate gastric regurgitation
(C) Prolonged digestion and absorption
(D) Activation of immune cell lines

2016

223. Dietary iron is primarily absorbed in the mammalian duodenum and proximal jejunum strictly in which chemical state?
(A) Ferric (Fe3+) state
(B) Ferrous (Fe2+) state
(C) Bound to transferrin
(D) Bound to ferritin

2025

224. Calcitriol (1,25-dihydroxycholecalciferol) acts intimately as a steroid hormone, initiating its physiological effects by binding to what?
(A) Extracellular G-protein coupled receptors
(B) Tyrosine kinase receptors
(C) Ion channel-linked receptors
(D) Intracellular nuclear receptors

2013

225. Clinical application of the Bromosulfophthalein (BSP) test has largely been replaced by the direct diagnostic measurement of which endogenous compound?
(A) Serum bile acids
(B) Serum cholesterol
(C) Serum triglycerides
(D) Serum glucose

2002

226. Estimation of Blood Urea Nitrogen (BUN) depends on the principle that urea is primarily synthesized in the liver via the urea cycle to detoxify what?
(A) Uric acid
(B) Ammonia
(C) Creatinine
(D) Bilirubin

2010

227. Physiological transient proteinuria can occur in normal domestic mammals following extreme events, such as what?
(A) Strenuous exercise or stress
(B) High carbohydrate meals
(C) Prolonged rest
(D) High water consumption

2004

228. Establishing accurate blood biochemistry reference intervals in wild animal populations necessitates statistical segregation based predominantly on what?
(A) Coat patterns
(B) Migration distance
(C) Vocalization types
(D) Age, sex, and season

2023

229. Immediate pathobiochemical treatment of acute capture myopathy in wildlife strongly emphasizes intravenous fluid therapy to prevent what?
(A) Acute hepatic failure pathology
(B) Myoglobinuric renal failure states
(C) Severe pulmonary edema development
(D) Spontaneous cerebral hemorrhage

2023

230. In studying wildlife pathobiochemistry, researchers track non-human primate diabetes progression by regularly monitoring which definitive marker?
(A) Serum C-reactive protein levels
(B) Total serum albumin concentration
(C) Glycated hemoglobin (HbA1c)
(D) Serum alkaline phosphatase activity

2017

231. Phase I reductions and hydrolyses primarily occur on xenobiotics that contain which specific reactive groups?
(A) Long-chain alkyl group chains
(B) Saturated aromatic ring systems
(C) Various halogenated alkanes
(D) Azo, nitro, and ester groups

2001

232. Sulfation of xenobiotics, primarily catalyzed by sulfotransferases in the cytosol, yields conjugates that are readily excreted into what fluid?
(A) Urine
(B) Bile
(C) Saliva
(D) Sweat

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2012

233. Total blood volume in a typical domestic canine is approximately what percentage of its total body weight?
(A) 2-4%
(B) 8-9%
(C) 15-20%
(D) 25-30%

2008

234. The Rapoport-Luebering shunt biochemically generates 2,3-BPG at the direct expense of producing which molecule in the glycolytic pathway?
(A) ATP
(B) Pyruvate
(C) Lactate
(D) NADH

2012

235. The fusion of the phagosome with the lysosome during macrophage phagocytosis exposes the engulfed pathogen to what lethal internal environment?
(A) Acidic pH and hydrolytic enzymes
(B) Highly alkaline pH environment
(C) Hyperosmotic sodium salt solution
(D) Absolute oxygen deprivation state

2002

236. Severe hepatic cirrhosis classically presents with an altered A:G ratio characterized by what distinct pattern?
(A) Elevated albumin and decreased globulins
(B) Decreased albumin and elevated globulins
(C) Normal albumin and decreased globulins
(D) Elevated albumin and elevated globulins

2007

237. The phenomenon where an increase in oxygen partial pressure powerfully displaces carbon dioxide from hemoglobin is specifically named the:
(A) Bohr effect
(B) Haldane effect
(C) Hamburger phenomenon
(D) Chloride shift

2017

238. In acid-base chemistry, the buffer capacity of any weak acid/conjugate base pair is mathematically and physiologically greatest when:
(A) pH equals $pKa + 2$
(B) pH equals $pKa - 2$
(C) pH equals pKa
(D) The acid is completely dissociated

2011

239. Renal ammonium excretion significantly increases during states of chronic metabolic acidosis to serve what primary physiological purpose?
(A) Excrete excess metabolic nitrogen waste
(B) Facilitate acid excretion and bicarbonate generation
(C) Conserve intracellular potassium ions
(D) Inhibit actions of parathyroid hormone

2025

240. The Cori cycle ensures metabolic continuity between the liver and skeletal muscle by continuously cycling which two key metabolites?
(A) Glucose and Lactate
(B) Glucose and Alanine
(C) Lactate and Pyruvate
(D) Glycogen and Glucose

2009

241. Chondroitin sulfate, the most abundant glycosaminoglycan in cartilage, is highly negatively charged due to the presence of which groups?
(A) Sulfate and carboxyl groups
(B) Phosphate and amino groups
(C) Hydroxyl and methyl groups
(D) Thiol and sulfhydryl groups

2015

242. Osteoblasts strictly regulate the local availability of phosphate for bone mineralization by secreting which specific enzyme?
(A) Acid phosphatase
(B) Pyrophosphatase
(C) Alkaline phosphatase
(D) Osteocalcin

2024

243. The fundamental biochemical difference between neurotransmitter synthesis in nerve terminals versus the soma involves the reliance on what?
(A) Local enzymatic reactions vs. axonal transport
(B) Fast DNA transcription in the synaptic area
(C) Ribosomal protein synthesis in the synaptic cleft
(D) Passive diffusion from surrounding glial cells

2014

244. During prolonged starvation, adipose tissue lipolysis profoundly increases the circulating blood levels of which metabolic substrates?
(A) Glucose and amino acids
(B) Glycogen and triglycerides
(C) Lactate and pyruvate
(D) Free fatty acids and glycerol

2023

245. Lactose is biochemically synthesized by linking galactose and glucose via which specific glycosidic bond?
(A) Alpha-1,4

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(B) Beta-1,4
(C) Alpha-1,6
(D) Beta-1,6

2017

246. Transferrin is typically only 30% saturated with iron in healthy animals. The total capacity of transferrin to bind iron is clinically measured as what?
(A) Serum ferritin
(B) Total Iron Binding Capacity (TIBC)
(C) Unsaturated iron-binding capacity (UIBC)
(D) Serum iron

2018

247. The primary biochemical trigger for the parathyroid glands to sharply increase the systemic secretion of PTH is:
(A) Rising serum ionized calcium
(B) Falling serum ionized calcium
(C) Rising serum calcitriol
(D) Falling serum phosphorus

2007

248. Hepatic diagnostic dye excretion tests, such as BSP, fundamentally evaluate the liver's capacity to perform which sequence of actions?
(A) Uptake, Conjugation, and Biliary Excretion
(B) Absorption, Storage, and Secretion
(C) Synthesis, Modification, and Renal Excretion
(D) Filtration, Reabsorption, and Degradation

2012

249. The presence of significant amounts of urinary casts (cylindruria) is definitively diagnostic for disease localized to which anatomical structure?
(A) Ureter
(B) Urinary bladder
(C) Renal tubules
(D) Urethra

2019

250. Complete physical urinalysis encompasses the direct diagnostic evaluation of color, clarity, and which other critical parameter?
(A) Glucose concentration
(B) Specific gravity
(C) Cell counts
(D) Bacterial cultures

2005

251. An extreme, acute physiological stress response in wild animals is frequently accompanied by a rapid, catecholamine-induced spike in what blood parameter?
(A) Glucose concentration
(B) Lymphocyte count
(C) Serum calcium
(D) Blood urea nitrogen

NODIA

2002

252. The pathobiochemical mechanism of capture myopathy is most directly analogous to which condition in domestic draft horses?
(A) Chronic equine metabolic syndrome
(B) Exertional rhabdomyolysis (tying-up)
(C) Acute clinical state of laminitis
(D) Equine Cushing's disease pathology

2007

253. Cheetahs suffering from leukoencephalomyelopathy pathobiochemically exhibit bilateral, symmetrical degeneration of white matter tracts primarily in the:
(A) Cerebrum
(B) Cerebellum
(C) Optic nerves
(D) Spinal cord

2006

254. The essential metabolic purpose of Phase II xenobiotic conjugation is to covalently link a parent toxicant or Phase I metabolite to what?
(A) A lipid-soluble carrier protein
(B) An inert and non-reactive hydrocarbon
(C) An endogenous, highly polar molecule
(D) A heavy metal cation like mercury

2009

255. Biliary excretion prominently clears xenobiotic conjugates that surpass a specific molecular weight threshold. In most mammals, this threshold is approximately:
(A) 50 - 100 Daltons
(B) 300 - 500 Daltons
(C) 1000 - 1500 Daltons
(D) 5000 - 10000 Daltons

2001

256. Which hematological parameter is calculated by dividing the hematocrit by the red blood cell count?
(A) Mean Corpuscular Hemoglobin (MCH)
(B) Mean Corpuscular Hemoglobin Concentration (MCHC)
(C) Red Cell Distribution Width (RDW)
(D) Mean Corpuscular Volume (MCV)

2009

257. Protection against oxidative stress in erythrocytes relies on glutathione reductase,

which uses NADPH derived exclusively from which pathway?
(A) Hexose monophosphate shunt
(B) Anaerobic glycolysis pathway
(C) Mitochondrial Krebs cycle
(D) Cellular beta-oxidation

2025

258. During platelet activation, the release of arachidonic acid from the membrane is definitively catalyzed by which specific phospholipase?
(A) Phospholipase C
(B) Phospholipase D
(C) Phospholipase A_2
(D) Phosphatidylinositol kinase

2002

259. Plasma protein electrophoresis normally resolves the globulin fraction into which distinct sub-bands?
(A) Alpha-1, Alpha-2, Beta, Gamma
(B) Alpha, Beta, Gamma, Delta
(C) Alpha, Beta-1, Beta-2, Epsilon
(D) Pre-alpha, Alpha, Beta, Gamma

2014

260. The tight binding of carbon monoxide to hemoglobin directly causes the oxygen dissociation curve of the remaining binding sites to shift in which direction?
(A) To the right, decreasing oxygen affinity
(B) Upward, increasing maximum capacity
(C) Downward, decreasing maximum capacity
(D) To the left, increasing oxygen affinity

2016

261. The most critical and rapidly responsive extracellular buffer system against non-volatile metabolic acids in mammals is:
(A) Cytoplasmic hemoglobin molecules
(B) Bicarbonate/carbonic acid system
(C) Circulating soluble plasma proteins
(D) Intracellular phosphate system

2004

262. In the proximal tubule, the enzyme carbonic anhydrase is strategically located both intracellularly and where else to facilitate bicarbonate reabsorption?
(A) Basolateral membrane
(B) Mitochondrial membrane
(C) Apical brush border membrane
(D) Nuclear envelope

2018

263. The Cori cycle transports lactate from muscle to liver; the corresponding glucose-alanine cycle performs a similar function but transports what to the liver?
(A) Long-chain fatty acids
(B) Systemic ketone bodies
(C) Concentrated glycerol
(D) Pyruvate and amino groups

2003

264. Vitamin C deficiency directly impairs the synthesis of normal collagen, culminating clinically in a systemic connective tissue disorder known as:
(A) Scurvy
(B) Rickets
(C) Osteomalacia
(D) Pellagra

2021

265. Biochemical markers of bone formation, directly secreted by osteoblasts, explicitly include which of the following?
(A) Tartrate-resistant acid phosphatase (TRAP)
(B) Bone-specific alkaline phosphatase (BALP)
(C) C-terminal telopeptide (CTX)
(D) Hydroxyproline

2011

266. Neurotransmitter vesicles are securely tethered to the presynaptic terminal cytoskeleton prior to calcium-induced exocytosis via a complex of proteins known as:
(A) Myelins
(B) SNARE proteins
(C) Connexins
(D) Cadherins

2016

267. Adipose tissue is highly endocrinologically active, secreting which crucial hormone that centrally signals satiety to the hypothalamus?
(A) Leptin
(B) Adiponectin
(C) Resistin
(D) Ghrelin

2008

268. The unique milk sugar lactose is synthesized inside the Golgi apparatus of the mammary epithelial cell, strictly utilizing which required precursor?
(A) ADP-glucose
(B) GDP-mannose
(C) UDP-galactose

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(D) CDP-choline

2016

269. Iron is rigidly conserved in the mammalian body. The primary pathway for obligate, daily physiological iron loss is through:
(A) Biliary excretion via the liver
(B) Renal excretion via the kidneys
(C) Pulmonary exhalation via lungs
(D) Desquamation of mucosal/epidermal cells

2016

270. Parathyroid hormone (PTH) rapidly increases serum calcium levels by directly activating which distinct process in bone?
(A) Triggering osteoblast apoptosis
(B) Active mineralization of osteoid
(C) Osteoclast-mediated bone resorption
(D) Direct inhibition of collagenase

2001

271. In the diagnosis of cholestasis, marked elevation of serum Alkaline Phosphatase (ALP) typically precedes the rise of which other classical marker?
(A) ALT
(B) Bilirubin
(C) AST
(D) Albumin

2021

272. Measuring the Glomerular Filtration Rate (GFR) accurately reflects the functional mass of which specific renal structure?
(A) Renal pelvis
(B) Loops of Henle
(C) Proximal tubules
(D) Functioning nephrons

2022

273. The biochemical presence of significant ketones (ketonuria) alongside glycosuria in a urinalysis fundamentally defines the diagnosis of what?
(A) Diabetic ketoacidosis
(B) Renal tubular acidosis
(C) Starvation
(D) High protein diet

2021

274. In wildlife pathobiochemistry, establishing standard baseline hematology requires analyzing blood strictly collected from animals that are:
(A) Under maximal physical restraint
(B) Recovering from chemical darting
(C) In a tranquilized, un-stressed state
(D) Captured via prolonged pursuit

2005

275. A classic pathobiochemical hallmark of capture myopathy is acute, massive release of intracellular muscle contents, frequently inducing terminal failure of which organ?
(A) Kidneys
(B) Liver
(C) Lungs
(D) Brain

2022

276. The pathogenesis of Type 2 diabetes mellitus in aging, captive non-human primates is intrinsically linked with the chronic development of what?
(A) Glucagon deficiency
(B) Autoimmune insulitis
(C) Severe iron overload
(D) Peripheral insulin resistance

2017

277. The Cytochrome P450 enzymes are biochemically characterized as hemoproteins because their active site rigidly incorporates what chemical group?
(A) A copper-zinc molecular complex
(B) An iron-protoporphyrin IX group
(C) A magnesium-based porphyrin ring
(D) A flavin adenine dinucleotide unit

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2021

278. The specific Phase II conjugation pathway that utilizes UDP-glucuronosyltransferase (UGT) to detoxify compounds is notoriously deficient in which domestic species?
(A) Dogs
(B) Horses
(C) Cats
(D) Swine

2023

279. The total volume of blood within the systemic circulation is physiologically regulated primarily by the kidneys modulating the reabsorption of what?
(A) Potassium and urea
(B) Calcium and phosphate
(C) Hydrogen and bicarbonate
(D) Sodium and water

2007

280. The Rapoport-Luebering shunt operates efficiently within mammalian erythrocytes exclusively because these cells lack the demand for high amounts of what?
(A) ATP for synthetic processes

(A) Mean Corpuscular Volume of erythrocytes (MCV)
(B) Mean Corpuscular Hemoglobin of erythrocytes (MCH)
(C) Mean Corpuscular Hemoglobin Concentration (MCHC)
(D) Red Cell Distribution Width of erythrocytes (RDW)

2024

211. In mammalian erythrocytes, the conversion of pyruvate to lactate is crucial to regenerate which coenzyme required for continuous glycolysis?
(A) NAD+
(B) NADH
(C) NADP+
(D) NADPH

2006

212. Which inflammatory mediator, synthesized during the macrophage respiratory burst, functions as a potent antimicrobial bleaching agent?
(A) Hydrogen peroxide
(B) Nitric oxide
(C) Superoxide
(D) Hypochlorous acid

2023

213. The acute phase protein C-Reactive Protein (CRP) migrates within which specific electrophoretic fraction of plasma proteins?
(A) Albumin
(B) Gamma globulin
(C) Alpha globulin
(D) Beta globulin

2010

214. The Haldane effect dictates that oxygenated blood has a significantly reduced capacity to carry which particular molecule?
(A) Carbon monoxide
(B) Nitrogen
(C) Carbon dioxide
(D) Hydrogen

2023

215. The primary intracellular buffering system in erythrocyte cytoplasm relies primarily on the high concentration of what?
(A) Bicarbonate
(B) Phosphate
(C) Carbonic acid
(D) Hemoglobin

2008

216. In the distal nephron, which principal buffer accepts secreted hydrogen ions to form titratable acidity?
(A) Monohydrogen phosphate
(B) Dihydrogen phosphate
(C) Gaseous ammonia molecules
(D) Soluble ammonium cations

2022

217. Skeletal muscle exhaustion during supramaximal exercise correlates strongly with the intracellular accumulation of which byproduct?
(A) Pyruvate
(B) Lactate and protons
(C) Glycogen
(D) Creatine phosphate

2014

218. The distinct structural resiliency of elastin is conferred by unique desmosine cross-links that strictly require the oxidation of which amino acid?
(A) Proline
(B) Lysine
(C) Glycine
(D) Arginine

2004

219. Biochemical markers of bone turnover are definitively categorized into markers of formation and markers of what?
(A) Resorption
(B) Mineralization
(C) Ossification
(D) Calcification

2003

220. Myelin lipid composition heavily features sphingomyelin, which structurally pairs a ceramide backbone with a head group containing what?
(A) Inositol
(B) Glucose
(C) Phosphocholine
(D) Galactose

2019

221. The biochemical pathway of lipogenesis utilizes Acetyl-CoA carboxylase, an enzyme that stringently requires which vitamin as a cofactor?
(A) Thiamine
(B) Riboflavin
(C) Niacin
(D) Biotin

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2019

292. Severe iodine deficiency during fetal development or early mammalian infancy results in a catastrophic pathobiochemical syndrome characterized by severe physical and mental retardation known as:
(A) Myxedema
(B) Goiter
(C) Graves' disease
(D) Cretinism

2019

293. The synthesis of Calcitriol in the kidney requires the activation of 1-alpha-hydroxylase, an enzyme that is directly and potently stimulated by what?
(A) Calcitonin
(B) Parathyroid hormone (PTH)
(C) Elevated serum calcium
(D) Elevated serum phosphate

2013

294. Bilirubin conjugation predominantly occurs in the endoplasmic reticulum of hepatocytes, utilizing which specific enzyme to form bilirubin diglucuronide?
(A) Biliverdin reductase
(B) Heme oxygenase
(C) UDP-glucuronosyltransferase
(D) Beta-glucuronidase

2023

295. Endogenous creatinine is derived completely from the spontaneous, non-enzymatic dehydration of muscle creatine. Consequently, daily creatinine production is directly proportional to what?
(A) Dietary protein intake
(B) Urine flow rate
(C) Hepatic synthesis capacity
(D) Total body muscle mass

2019

296. The fundamental principle of a urine dipstick for detecting pathological proteinuria relies primarily on the "protein error of indicators," which is most exquisitely sensitive to what?
(A) Albumin
(B) Bence-Jones proteins
(C) Globulins
(D) Glycoproteins

2004

297. Physiological fluid and electrolyte shifts in wild herbivores during immobilization frequently cause a rapid, stress-induced decrease in the serum concentration of which ion?
(A) Sodium
(B) Potassium
(C) Chloride
(D) Calcium

2010

298. The specific pathobiochemical mechanism triggering acute death in severe wildlife capture myopathy is frequently profound hyperkalemia resulting in what?
(A) Fatal cardiac arrhythmias
(B) Respiratory paralysis
(C) Hepatic rupture
(D) Cerebral edema

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2024

299. Managing captive non-human primates strictly requires regular biochemical monitoring to prevent obesity-induced insulin resistance, directly mitigating the onset of what?
(A) Type 2 Diabetes
(B) Type 1 Diabetes
(C) Diabetes Insipidus
(D) Pancreatic exocrine insufficiency

2017

300. The Cytochrome P450 monooxygenase cycle fundamentally terminates with the rapid transfer of the second electron, triggering the immediate cleavage of the oxygen bond to release what?
(A) Hydrogen peroxide and the unchanged substrate
(B) Two molecules of water
(C) The hydroxylated product and a molecule of water
(D) A free radical superoxide and the product

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(B) High amounts of NADH
(C) Intracellular hemoglobin
(D) Continuous glucose supply

2005

281. Following pathogen engulfment, the macrophage respiratory burst rapidly demands a massive increase in the cellular consumption of what?
(A) Carbon dioxide
(B) Molecular oxygen
(C) Nitrogen
(D) Hydrogen

2011

282. Which distinct plasma protein fraction contains alpha-1 antitrypsin, a critical protease inhibitor protecting tissues from inflammatory enzymes?
(A) Alpha-1 globulin
(B) Prealbumin
(C) Beta globulin
(D) Gamma globulin

2016

283. Hemoglobin functionally undergoes a transition from the T (tense) state to the R (relaxed) state. This structural change is immediately triggered by what?
(A) First oxygen molecule binding
(B) Binding of 2,3-BPG molecules
(C) Binding of individual protons
(D) Binding of gaseous carbon dioxide

2009

284. According to the Henderson-Hasselbalch equation, the physiological ratio of bicarbonate to dissolved carbon dioxide at normal blood *pH* (7.4) is approximately:
(A) 10:1
(B) 1:20
(C) 20:1
(D) 1:1

2014

285. In the regulation of systemic acid-base balance, the renal response to chronic acidosis is characterized by a significant upregulation of enzymes involved in what?
(A) Glycolysis and lactate production
(B) Beta-oxidation and ketogenesis
(C) Urea cycle and ammonia detox
(D) Gluconeogenesis and glutamine metabolism

2006

286. Muscle fatigue during intense anaerobic exercise is fundamentally characterized by a precipitous decline in intracellular pH, directly inhibiting which regulatory enzyme?
(A) Lactate dehydrogenase
(B) Creatine kinase
(C) Phosphofructokinase
(D) Adenylate kinase

2018

287. Fibronectin functions as a crucial extracellular matrix adhesive glycoprotein strictly by possessing specific binding domains for both collagen and what?
(A) Soluble plasma albumin protein
(B) Cell surface integrin receptors
(C) Circulating immunoglobulins (IgG)
(D) Intracellular filamentous actin

2015

288. In the evaluation of systemic bone turnover, Tartrate-Resistant Acid Phosphatase (TRAP) is universally recognized as a specific biochemical marker for what?
(A) Osteoblast proliferation
(B) Osteocyte apoptosis
(C) Chondrocyte hypertrophy
(D) Osteoclast activity

2006

289. Energy metabolism in the brain relies almost exclusively on glucose; however, the transport of glucose across the blood-brain barrier is heavily dependent on which specific transporter?
(A) GLUT-1
(B) SGLT-1
(C) GLUT-4
(D) GLUT-2

2001

290. Hormone-sensitive lipase in adipose tissue is definitively phosphorylated and activated by Protein Kinase A, which acts immediately downstream of what?
(A) Insulin receptor binding
(B) Elevated intracellular cGMP
(C) Elevated intracellular cAMP
(D) Calcium-calmodulin complex

2009

291. Milk proteins are almost exclusively synthesized within the mammary alveolar cells, with the notable exception of which proteins derived directly from maternal blood?
(A) Immunoglobulins
(B) Caseins
(C) Alpha-lactalbumin
(D) Beta-lactoglobulin

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amino acid, occurs at every third position in the primary sequence. Its presence is essential for the tight packing and stability of the collagen fiber.

10. (B) Alkaline phosphatase
Alkaline phosphatase is a key enzyme involved in the mineralization of the bone matrix. It is produced by osteoblasts and functions to increase local concentrations of inorganic phosphate. While several isoforms exist, the bone-specific fraction is a standard clinical marker for monitoring bone formation. Elevated levels in the blood typically reflect increased osteoblastic activity or rapid bone growth in animals.

11. (A) Glycosphingolipids
Cerebrosides are specialized lipids found predominantly in the myelin sheaths of nerve tissue. They consist of a ceramide backbone covalently bonded to a single sugar residue, such as glucose or galactose. Because they contain both a sphingosine-based lipid component and a carbohydrate group, they are fundamentally classified as glycosphingolipids. They play critical roles in cell signaling and membrane stability.

12. (B) II and IV
Brown adipose tissue is specialized for thermogenesis due to high mitochondrial density and the presence of uncoupling protein-1. White adipose tissue serves primarily as an energy storage site and does not utilize UCP-1 for heat production. Furthermore, insulin acts as an anabolic hormone that promotes lipogenesis and inhibits lipolysis, making statements regarding white fat UCP-1 and insulin-inhibited lipogenesis incorrect.

13. (D) Prolactin
Prolactin is a peptide hormone secreted by the anterior pituitary gland that plays a central role in mammary gland development. It serves as the primary stimulus for the synthesis of milk proteins, such as caseins and lactalbumin, within the alveolar epithelial cells. The hormonal shift at the end of pregnancy triggers prolactin activity, initiating the physiological process of lactogenesis in mammals.

14. (C) Transferrin
Transferrin is the primary glycoprotein synthesized by the liver for the transport of iron through the systemic circulation. It binds ferric iron with high affinity, ensuring that the metal remains soluble and non-toxic while moving between absorption sites and storage tissues. This transport mechanism is vital for delivering iron to the bone marrow for the synthesis of new hemoglobin molecules.

15. (B) Calbindin
Calcitriol, the active form of Vitamin D, acts as a hormone to maintain calcium homeostasis. It enters intestinal epithelial cells and binds to nuclear receptors to stimulate the transcription of specific genes. One of the primary proteins produced is calbindin, which functions as an intracellular transporter. Calbindin facilitates the movement of calcium across the enterocyte, significantly increasing the efficiency of intestinal absorption.

16. (D) Liver
The Bromosulfophthalein clearance test is a diagnostic tool used to assess the functional capacity of the liver. When the dye is injected intravenously, healthy hepatocytes efficiently remove it from the blood and excrete it into the bile. A delayed clearance rate indicates impaired hepatic blood flow or reduced secretory function, making it a sensitive indicator of various liver diseases in animals.

17. (A) II, IV and V
Creatinine originates from muscle creatine phosphate and provides a reliable measure of kidney function because it is freely filtered by the glomerulus. Markers for glomerular filtration rate must be freely filtered and not reabsorbed or secreted, with inulin serving as the physiological gold standard. Serum creatinine levels are inversely proportional to filtration rates, and urea levels are influenced by diet.

18. (A) Fat mobilization, Hepatic ketogenesis, Ketonemia, Renal excretion
The development of severe ketonuria begins with the mobilization of free fatty acids from adipose tissue. These fatty acids travel to the liver, where they undergo beta-oxidation and are converted into ketone bodies through hepatic ketogenesis. As ketone levels rise in the blood, a state of ketonemia occurs. Once the renal threshold is exceeded, the excess ketones are eliminated through renal excretion.

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molecular bridges because they possess specific binding sites that are recognized by receptors on the macrophage surface. This receptor-mediated attachment ensures a strong connection, facilitating the rapid engulfment of the pathogen.

73. (B) Alpha and beta globulins
During an inflammatory response, the liver rapidly increases the synthesis of specialized proteins known as acute phase reactants. These proteins play diverse roles in the immune response, including tissue repair and pathogen neutralization. Most of these reactants, such as fibrinogen and haptoglobin, are found within the alpha and beta globulin fractions during electrophoretic separation. Monitoring these fractions provides clinicians with important information regarding the presence and severity of systemic inflammation.

74. (B) Ionic (salt) bridges
2,3-bisphosphoglycerate is a highly negatively charged molecule that serves as a key allosteric regulator of hemoglobin. It binds to a specific pocket between the two beta chains in the deoxygenated form. The stabilization of this binding is achieved through the formation of ionic bonds, or salt bridges, between the negative groups of 2,3-BPG and the positively charged amino acid residues of the hemoglobin molecule. This interaction reduces oxygen affinity.

75. (A) Increased pH
When a blood sample is exposed to air, carbon dioxide gas rapidly diffuses out of the liquid phase into the atmosphere. According to the bicarbonate buffering system, a decrease in dissolved carbon dioxide leads to a reduction in carbonic acid levels. This shift results in a decrease in the concentration of hydrogen ions, causing the pH of the sample to rise artifactually. Proper sample handling is essential to avoid such diagnostic errors.

76. (C) Sodium
The reabsorption of bicarbonate in the proximal convoluted tubule is intrinsically linked to the secretion of hydrogen ions. This process is driven by a specialized sodium-hydrogen antiporter located on the apical membrane of the tubular cells. As sodium ions are reabsorbed from the lumen into the cell down their concentration gradient, hydrogen ions are actively pumped out. This exchange is essential for maintaining both electrolyte balance and systemic acid-base stability.

77. (B) P-3, Q-1, R-4, S-2
Muscle fibers and metabolic processes show specialized adaptations for physical activity. Type I fibers are oxidative and resistant to fatigue, while Type IIb fibers are glycolytic and fatigue quickly. The Cori cycle facilitates the recycling of lactate back into glucose within the liver. Myoglobin serves as a vital protein for oxygen storage in muscle tissue, ensuring a steady supply during contraction.

78. (C) Hyaluronic acid
Hyaluronic acid is a massive, unsulfated glycosaminoglycan that serves as a central structural component of the cartilage extracellular matrix. It forms a long, linear backbone that allows multiple proteoglycan monomers to attach via specialized link proteins. This assembly creates large multimeric aggregates that trap water and provide the tissue with its characteristic resilience. These networks act as a scaffold, ensuring the organized distribution of other matrix molecules.

79. (B) Calcium and Phosphate
Bone mineralization is the process by which inorganic minerals are deposited into the organic osteoid matrix. This biological crystallization is fundamentally dependent on maintaining optimal local concentrations of calcium and phosphate ions. When the solubility product of these two ions is exceeded, they precipitate to form hydroxyapatite crystals. The precise regulation of these ion levels by osteoblasts ensures that bone tissue achieves the necessary hardness and structural strength.

80. (D) Sphingosine
Sphingolipids are a diverse class of lipids that serve as essential structural components of cell membranes, particularly in the nervous system. Unlike phospholipids, which are built on glycerol, sphingolipids utilize the long-chain amino alcohol sphingosine as their core backbone. When a fatty acid is attached to the amino group of sphingosine, a ceramide is formed. Ceramides serve as the precursor for more complex sphingolipids, including sphingomyelin and various glycosphingolipids.

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28. (C) Binding of one oxygen molecule hinders the binding of subsequent molecules.
Hemoglobin displays cooperative binding, meaning the attachment of the first oxygen molecule actually increases the affinity for subsequent molecules. This causes the characteristic sigmoidal shape of the dissociation curve. Allosteric factors like high hydrogen ion concentration and 2,3-BPG levels stabilize the deoxygenated tense state. These factors shift the curve to the right, facilitating the delivery of oxygen to tissues during metabolism.

29. (A) I and III
The Henderson-Hasselbalch equation is a fundamental tool in acid-base biochemistry that relates the pH of a solution to the pKa and the ratio of conjugate base to weak acid. It is used extensively in clinical settings to analyze blood gas results and evaluate systemic pH balance. The equation does not assume complete dissociation, as it specifically describes the behavior of weak acids.

30. (C) Proximal convoluted tubule
The proximal convoluted tubule is the primary site for the reclamation of filtered bicarbonate in the kidney. Approximately eighty to ninety percent of the bicarbonate filtered by the glomerulus is reabsorbed in this segment. This process involves the secretion of hydrogen ions and the action of carbonic anhydrase, which ensures that the vital buffering capacity of the blood is maintained.

31. (B) II and IV
Muscle tissue exhibits distinct biochemical and structural characteristics depending on its type. Skeletal and cardiac muscles are striated, whereas smooth muscle lacks striations but still contains actin and myosin filaments. While cardiac muscle is highly dependent on aerobic metabolism rather than anaerobic glycolysis, ATP and creatine phosphate are universal energy sources used during the initial stages of muscle exertion and contraction.

32. (D) Proteoglycans
Proteoglycans are major components of the cartilage extracellular matrix that consist of a core protein attached to glycosaminoglycan chains. Due to their high negative charge, they attract large amounts of water, creating significant osmotic pressure. This hydration provides cartilage with its characteristic compressive resilience and shock-absorbing properties, allowing joints to withstand mechanical loads without sustaining permanent structural damage or deformation.

33. (A) I, II and V
Bone tissue biochemistry involves a matrix called osteoid, which is primarily composed of Type I collagen. Mineralization occurs when hydroxyapatite crystals, containing calcium and phosphorus, deposit within this matrix. Osteoclasts are responsible for bone resorption rather than formation, and calcitonin inhibits this process. Acid phosphatase serves as a specific biochemical marker for osteoclast activity, reflecting the rate of bone mineral breakdown.

34. (C) Ketone bodies
The brain typically relies on glucose as its primary fuel source because fatty acids cannot cross the blood-brain barrier. However, during prolonged starvation or carbohydrate deprivation, the liver produces ketone bodies from fatty acids. These ketone bodies, such as acetoacetate and beta-hydroxybutyrate, can cross into the brain. Neurons then utilize these substrates to generate ATP, ensuring survival during energy shortages.

35. (A) ATGL, HSL, MGL
Lipolysis in adipose tissue involves the sequential breakdown of triglycerides into free fatty acids and glycerol. Adipose triglyceride lipase initiates the process by converting triglycerides to diglycerides. Hormone-sensitive lipase then hydrolyzes diglycerides into monoglycerides. Finally, monoglyceride lipase completes the cascade by breaking down monoglycerides. This coordinated enzymatic activity ensures the efficient mobilization of stored energy during fasting or increased metabolic demand.

36. (D) UDP-galactose
Lactose synthesis occurs within the Golgi apparatus of mammary alveolar cells. The process is catalyzed by the lactose synthase enzyme complex, which consists of galactosyltransferase and alpha-lactalbumin. The biochemical reaction requires the transfer of a galactose unit from the high-energy donor, UDP-galactose, to a glucose molecule. This synthesis is essential for providing the primary carbohydrate source in the milk of mammals.

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19. (A) Isoantibodies
Blood typing in wild animal species is complicated by the presence of naturally occurring isoantibodies. These are antibodies found in the plasma that react against specific antigens present on the erythrocytes of other individuals within the same species. Their presence can lead to life-threatening hemolytic reactions during transfusions, necessitating careful cross-matching and specialized typing procedures for wildlife management and veterinary care.

20. (D) Creatine kinase
Creatine kinase is an enzyme found in high concentrations within skeletal and cardiac muscle tissues. When muscle cells are damaged during the extreme physical exertion associated with capture myopathy, this enzyme leaks into the systemic circulation. Consequently, a marked elevation in serum creatine kinase activity serves as the most sensitive and distinct diagnostic indicator of muscle injury in captured wild animals.

21. (B) Cheetahs
Leukoencephalomyelopathy is a progressive neurological disorder characterized by the degeneration of white matter in the central nervous system. This condition has been specifically documented in captive cheetah populations. Affected animals typically exhibit ataxia, paresis, and other motor deficits. While the exact etiology remains under investigation, it involves significant pathobiochemical changes within the myelin sheaths of the brain and the spinal cord.

22. (B) II, III, I, IV
The Cytochrome P450 catalytic cycle follows a strict sequence of biochemical events. First, the substrate binds to the oxidized form of the enzyme. This is followed by the first electron transfer, which reduces the iron atom. Next, molecular oxygen binds to the complex, leading to a second reduction and oxygen activation. Finally, the hydroxylated product is released, regenerating the starting enzyme.

23. (D) UDP-glucuronic acid
Glucuronidation is a major Phase II detoxification pathway that increases the water solubility of various xenobiotics. This reaction is catalyzed by UDP-glucuronosyltransferases, which transfer a glucuronic acid moiety to the substrate. The essential high-energy donor for this process is uridine diphosphate glucuronic acid. By attaching this polar sugar, the body facilitates the rapid excretion of toxic compounds through the urine or bile.

24. (A) Estimating total plasma volume
Evans Blue, also known as T-1824, is a dye that binds strongly and specifically to serum albumin. When a known amount is injected into the bloodstream, it remains within the vascular compartment for a sufficient period. By measuring the final concentration of the dye after it has thoroughly mixed, clinicians can mathematically calculate the total plasma volume using the dilution principle.

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25. (C) A is true but R is false.
The hexose monophosphate pathway is indispensable for erythrocyte survival because it generates NADPH, which maintains reduced glutathione to combat oxidative stress. However, the reduction of methemoglobin back to functional hemoglobin primarily relies on the NADH-dependent cytochrome b5 reductase enzyme rather than the NADPH generated by the HMP shunt. Thus, while the pathway is vital, the specific reasoning provided is incorrect.

26. (B) Thromboxane A_2
Thromboxane A_2 is a potent lipid mediator synthesized from arachidonic acid within activated platelets. Once released, it binds to specific receptors on the surface of nearby platelets, triggering a signaling cascade that promotes further activation and aggregation. This process is essential for the formation of a stable platelet plug at sites of vascular injury, acting as a key driver of hemostasis.

27. (A) P-3, Q-4, R-1, S-2
Plasma proteins perform diverse physiological roles within the circulatory system. Albumin is the primary contributor to oncotic pressure, preventing fluid leakage into tissues. Transferrin facilitates the safe transport of iron through the bloodstream. Fibrinogen is a critical glycoprotein that initiates the coagulation cascade to prevent blood loss. Immunoglobulins provide humoral immunity by identifying and neutralizing foreign pathogens during the immune response.

increases the water solubility of these compounds for excretion.

46. (C) Sulfhydryl group
Glutathione is a tripeptide that plays a vital role in Phase II detoxification reactions. The molecule contains a cysteine residue, which provides a highly reactive sulfhydryl group. The enzyme glutathione S-transferase facilitates the conjugation of this sulfhydryl group to electrophilic xenobiotics. This binding neutralizes the reactive compounds and significantly increases their polarity, making them easier for the kidneys or liver to eliminate.

47. (B) I and III
Hematocrit levels reflect the proportion of red blood cells in the circulation. A decrease in this value is most commonly caused by anemia, where the total number of erythrocytes is reduced. Severe hemorrhage also leads to a loss of both plasma and cells, resulting in a lower hematocrit as the body replaces lost volume with interstitial fluid. Dehydration actually causes an increase.

48. (D) Increased oxidative hemolysis
Glucose-6-phosphate dehydrogenase is the rate-limiting enzyme of the hexose monophosphate pathway in erythrocytes. This pathway is the only source of NADPH, which is required to maintain reduced glutathione levels. A deficiency in this enzyme impairs the cell's ability to neutralize reactive oxygen species. Consequently, erythrocytes become highly susceptible to oxidative stress, leading to the precipitation of hemoglobin and accelerated cell destruction.

49. (A) Respiratory burst
The respiratory burst is a critical component of the innate immune response in phagocytic cells like macrophages. Upon activation, these cells significantly increase their oxygen consumption to generate superoxide anions and other reactive oxygen species. This rapid metabolic shift is catalyzed by NADPH oxidase. The produced radicals are highly toxic to engulfed microorganisms, facilitating their destruction within the phagolysosome during the process of phagocytosis.

50. (C) Chronic inflammation or liver disease
The Albumin:Globulin ratio is a clinical indicator derived from the concentrations of these major plasma protein fractions. A decrease in this ratio occurs when albumin levels fall or globulin levels rise. Liver disease reduces the synthesis of albumin, while chronic inflammation leads to increased production of immunoglobulins and other acute-phase proteins. Monitoring this ratio helps clinicians identify underlying systemic pathologies and immune activations.

51. (A) Carbon dioxide and protons
The Bohr effect describes the physiological phenomenon where hemoglobin's oxygen-binding affinity is inversely related to acidity and carbon dioxide concentration. In tissues with high metabolic activity, the accumulation of protons and CO_2 stabilizes the deoxygenated form of hemoglobin. This shift facilitates the release of oxygen where it is needed most. Conversely, in the lungs, lower concentrations of these factors promote oxygen binding.

52. (B) II
The Henderson-Hasselbalch equation describes the relationship between pH, pKa, and the concentrations of a weak acid and its conjugate base. It is a vital tool for analyzing physiological blood gas results and understanding how buffer systems function, particularly near their pKa values. However, it is not used to determine the isoelectric point of proteins, as that property depends on the amino acid composition.

53. (B) Glutamine
Renal ammonium excretion is a primary mechanism for the elimination of metabolic acids and the generation of new bicarbonate. This process begins in the proximal tubular cells, where the amino acid glutamine is metabolized. The enzyme glutaminase breaks down glutamine into glutamate and ammonium ions. The ammonium is subsequently secreted into the tubular lumen, while the generated bicarbonate is returned to the circulation.

54. (C) Creatine kinase
Creatine kinase is an essential enzyme in muscle energy metabolism. During periods of high demand, it catalyzes the reversible transfer of a high-energy phosphate group from creatine phosphate to ADP. This reaction rapidly regenerates ATP, providing an immediate energy source for muscle contraction before other metabolic pathways are fully activated. The presence of this enzyme in the blood is a marker for muscle damage.

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55. (D) Gly-X-Y triple helical structure
Elastin and collagen are both vital components of the extracellular matrix, but they possess distinct biochemical structures. Collagen is defined by a rigid triple helix composed of repeating Gly-X-Y amino acid sequences. In contrast, elastin is a highly flexible protein that lacks this regular helical structure. Its elasticity is derived from hydrophobic interactions and unique cross-links like desmosine, allowing tissues to stretch and recoil.

56. (A) Osteocalcin
Osteocalcin is a non-collagenous protein synthesized by osteoblasts during bone formation. It contains gamma-carboxyglutamic acid residues that allow it to bind calcium ions with high affinity. Within the osteoid matrix, osteocalcin plays a critical role in regulating the nucleation and growth of hydroxyapatite crystals. Because its synthesis is dependent on Vitamin K, it serves as a systemic marker for bone mineralization and turnover.

57. (B) I, II and III
Neurotransmitter metabolism involves specific enzymes for synthesis and degradation to ensure precise signaling. Acetylcholinesterase breaks down acetylcholine, while monoamine oxidase degrades catecholamines like norepinephrine. GABA is an inhibitory neurotransmitter synthesized from glutamate. Serotonin is actually derived from tryptophan, not tyrosine, and dopamine is typically excitatory or inhibitory depending on the receptor, but glycine is the primary inhibitory transmitter in the spinal cord.

58. (B) Thermogenin (UCP-1)
The primary difference between white and brown adipose tissue lies in their mitochondrial function. Brown fat contains a specialized protein called thermogenin, or uncoupling protein-1, located in the inner mitochondrial membrane. This protein allows protons to leak back into the matrix without passing through ATP synthase. Instead of producing chemical energy, the proton gradient is dissipated as heat, providing a vital thermogenic mechanism.

59. (A) C16 (Palmitic acid)
De novo fatty acid synthesis in the mammary gland involves the assembly of two-carbon units into longer chains. This process utilizes the fatty acid synthase enzyme complex. In most mammalian species, this synthesis typically proceeds until a chain length of sixteen carbons, known as palmitic acid, is reached. These fatty acids are subsequently incorporated into triglycerides, forming the major lipid component of milk during the lactation period.

60. (C) Hepcidin
Hepcidin is a peptide hormone synthesized by the liver that serves as the master regulator of systemic iron homeostasis. It controls iron levels by binding to ferroportin, the protein responsible for exporting iron from enterocytes into the blood. When iron stores are sufficient, hepcidin levels rise, leading to the degradation of ferroportin. This action effectively reduces the intestinal absorption of dietary iron and restricts its release from macrophages.

61. (D) Osteoclasts
Calcitonin is a hormone produced by the parafollicular cells of the thyroid gland in response to high blood calcium. Its primary function is to lower systemic calcium levels by directly inhibiting the activity of osteoclasts. By reducing the rate of bone resorption, calcitonin prevents the release of calcium and phosphate into the circulation. This hormonal action serves as a counter-regulatory mechanism to parathyroid hormone.

62. (A) ALT, AST, ALP
In small animal clinical enzymology, ALT is considered the most specific marker for hepatocellular damage because it is primarily located within the liver cell cytoplasm. AST is also present in the liver but is found in muscle and other tissues as well. ALP is associated with the biliary system and bone. Therefore, the relative specificity for indicating direct liver cell injury follows the order of ALT, AST, then ALP.

63. (B) Serum creatinine
The glomerular filtration rate is the most reliable measure of overall renal function. Creatinine is a metabolic byproduct that is produced at a constant rate and eliminated almost entirely by glomerular filtration. When the GFR decreases due to kidney disease, the kidneys are unable to filter creatinine efficiently. This results in a predictable and measurable elevation of serum creatinine levels, making it a standard diagnostic marker.

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64. (D) Exceeding the renal glucose threshold
Glucose is normally filtered by the glomerulus and completely reabsorbed by the proximal tubules, resulting in glucose-free urine. However, the tubular transport mechanism has a maximum capacity known as the renal threshold. If blood glucose levels rise excessively, as seen in diabetes mellitus, the filtered load exceeds this threshold. The tubules cannot reabsorb the excess glucose, leading to its excretion in the urine, a condition called glycosuria.

65. (A) Nutritional metabolic pathways
Hematological differences between wild herbivores and carnivores are primarily driven by their distinct dietary patterns and associated metabolic requirements. Herbivores often rely on fermentation and specialized pathways to process complex plant carbohydrates, while carnivores have adaptations for high-protein diets. These nutritional differences influence baseline values for parameters such as red blood cell counts and hemoglobin concentrations, reflecting the unique physiological demands of each dietary niche.

66. (C) Acute physiological stress
Cortisol is a glucocorticoid hormone released by the adrenal cortex as part of the hypothalamic-pituitary-adrenal axis response. In wild animals, the process of capture and restraint triggers a significant increase in circulating cortisol levels. This hormone serves as a reliable systemic biomarker for acute physiological stress. Elevated cortisol helps mobilize energy reserves and modulate the immune system, providing a measurable indicator of the animal's immediate stress experience.

67. (A) II, IV, I, III
Leukoencephalomyelopathy in cheetahs develops through a complex sequence of events. It begins with an initial trigger, potentially genetic or nutritional in nature. This leads to the activation of glial cells and the onset of neuroinflammation within the central nervous system. As a result, demyelination occurs in the spinal cord, disrupting nerve signal transmission. The final clinical manifestation is the progressive development of ataxia and paresis.

68. (D) Oxidation
Phase I xenobiotic metabolism involves reactions that introduce or expose polar functional groups on a substrate. Oxidation is the most common type of Phase I reaction and is typically mediated by the Cytochrome P450 system. This process requires molecular oxygen and the coenzyme NADPH to function correctly. By adding an oxygen atom, the enzyme increases the compound's reactivity and water solubility, facilitating its subsequent conjugation and excretion.

69. (B) PAPS (active sulfate donor molecule)
Sulfation is a vital Phase II detoxification reaction that increases the water solubility of various endogenous and exogenous compounds. This process is catalyzed by sulfotransferases, which transfer a sulfate group to the target molecule. The reaction requires a specific high-energy donor known as 3-phosphoadenosine-5-phosphosulfate. By attaching this polar sulfate group, the body ensures that the resulting metabolite can be easily eliminated through the urinary system.

70. (C) Evans Blue or T-1824
Estimating total blood volume relies on the indicator dilution principle, which requires a substance that remains within the vascular compartment. Evans Blue dye, also known as T-1824, is commonly used because it binds firmly to plasma albumin. By injecting a known quantity and measuring its final concentration in the plasma, clinicians can calculate the total plasma volume. This value, combined with the hematocrit, allows for the determination of total blood volume.

71. (D) Mitochondria
Mammalian erythrocytes are highly specialized cells that lack most organelles, including mitochondria. Because mitochondria are the site of aerobic respiration and the Krebs cycle, these cells are unable to utilize oxygen for energy production. Instead, erythrocytes rely entirely on anaerobic glycolysis to generate ATP. This adaptation ensures that the oxygen they carry is not consumed by the cell itself, maximizing the amount delivered to other tissues.

72. (A) Both A and R are true and R is the correct explanation of A.
Phagocytosis is the process by which macrophages engulf and destroy foreign particles. This process is significantly more efficient when the particles are coated with opsonins, such as IgG antibodies or C3b complement proteins. Opsonins act as

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37. (A) Both A and R are true and R is the correct explanation of A.
Iodine is an essential component of thyroid hormones. When dietary intake is insufficient, the production of thyroxine and triiodothyronine decreases. This reduction removes the negative feedback inhibition on the pituitary gland, leading to increased secretion of thyroid-stimulating hormone. Chronic TSH stimulation causes the follicular cells of the thyroid gland to enlarge and multiply, resulting in the clinical condition known as goiter.

38. (C) Hypocalcemia
The parathyroid glands monitor the concentration of ionized calcium in the blood through specialized calcium-sensing receptors. When levels drop below the physiological set point, a condition known as hypocalcemia, the glands immediately release parathyroid hormone. PTH acts on the kidneys and bones to increase blood calcium levels. This rapid hormonal response is a critical mechanism for maintaining systemic mineral homeostasis in domestic animals.

39. (A) II, I, III, IV
Bilirubin metabolism begins with the degradation of heme into biliverdin, which is subsequently reduced to unconjugated bilirubin. This bilirubin is transported to the liver and conjugated with glucuronic acid to increase its solubility. Conjugated bilirubin is then excreted into the bile and enters the intestine. Finally, intestinal bacteria reduce it to urobilinogen, which is either excreted in feces or reabsorbed.

40. (A) High protein diet
Blood Urea Nitrogen is a byproduct of protein metabolism produced in the liver through the urea cycle. While BUN is commonly used to assess renal function, its levels are sensitive to the amount of protein consumed. A high protein diet increases the production of ammonia, which the liver converts to urea. Consequently, elevated BUN levels may reflect dietary intake rather than underlying disease.

41. (B) Multiple myeloma
Bence-Jones proteins are monoclonal immunoglobulin light chains produced in excessive quantities by malignant plasma cells. In cases of multiple myeloma, these small proteins are filtered by the glomerulus and appear in the urine. Their detection is a hallmark of this plasma cell dyscrasia. Routine urinalysis using heat precipitation or specialized electrophoresis is utilized to identify these proteins during the diagnostic process.

42. (A) P-4, Q-1, R-2, S-3
Wildlife pathobiochemistry utilizes specific markers to assess animal health and stress levels. Capture myopathy is characterized by significant elevations in creatine kinase due to muscle damage. The physiological stress response is typically measured by increased systemic cortisol levels. Diabetes mellitus is frequently documented in non-human primate species. Leukoencephalomyelopathy is a progressive neurological disorder that has been specifically observed and documented in captive cheetah populations.

43. (A) Hemoconcentration
During the acute stress and intense physical exertion of wildlife capture, several physiological changes occur. The release of catecholamines and the activation of the splenic contraction mechanism force stored erythrocytes into the circulation. Simultaneously, fluid shifts from the vascular space to the interstitial compartment. These combined factors result in hemoconcentration, which is reflected as an increase in the hematocrit and total protein levels.

44. (C) Insulin resistance linked to obesity
Diabetes mellitus in captive non-human primates is predominantly characterized by the failure of tissues to respond appropriately to insulin. This insulin resistance is often a direct consequence of obesity and lack of physical activity in a captive environment. While the pancreas initially increases insulin production to compensate, the sustained metabolic demand eventually leads to beta-cell exhaustion and chronic hyperglycemia, mimicking human type 2 diabetes.

45. (D) Smooth endoplasmic reticulum
The Cytochrome P450 enzyme complex is the primary system for Phase I xenobiotic metabolism. These enzymes are integral membrane proteins located predominantly within the smooth endoplasmic reticulum of hepatocytes. This organelle provides the necessary lipid environment for these hydrophobic enzymes to interact with various toxins and drugs. By catalyzing oxidation reactions, the P450 system

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81. (A) NADPH
Lipogenesis is the metabolic process that converts excess acetyl-CoA into fatty acids for energy storage. This pathway requires a significant source of reducing power to drive the chemical reactions. The coenzyme NADPH serves as the primary electron donor for fatty acid synthesis. In adipose tissue, the hexose monophosphate shunt is the major metabolic pathway responsible for generating the NADPH necessary to support these biosynthetic activities.

82. (A) I and II
Mammary gland metabolism is specialized for the production of milk components during lactation. Milk protein synthesis, including caseins, requires a steady supply of essential amino acids from the blood. Milk lipids are unique because they form true emulsions, which ensures their stability and digestibility. While lipid and protein synthesis occur in various organelles, lactose synthesis specifically takes place within the Golgi apparatus rather than the rough endoplasmic reticulum.

83. (A) Ferritin
Ferritin is the primary intracellular protein responsible for the safe and efficient storage of iron. It forms a hollow, spherical shell that can sequester thousands of iron atoms in a non-toxic ferric form. This mechanism prevents the metal from participating in reactive oxygen species generation, protecting cellular components from oxidative damage. When systemic iron levels are low, the stored iron can be mobilized and released into the circulation for use.

84. (D) Flaccid paralysis (milk fever)
Milk fever is a metabolic disorder that occurs in high-producing dairy cows shortly after calving. The sudden onset of lactation causes a massive drain on systemic calcium levels, leading to severe hypocalcemia. Unlike other species, this condition in cattle typically manifests as flaccid paralysis because low calcium impairs the release of acetylcholine at the neuromuscular junction. Without adequate neurotransmitter release, muscle contraction fails, resulting in the characteristic inability to stand.

85. (B) Cholestasis (biliary stasis)
Gamma-glutamyl transferase is an enzyme associated with the membranes of cells lining the biliary tract. While it is present in the liver, its activity in the blood increases most significantly during conditions that cause bile stasis or cholestasis. Unlike ALT, which indicates direct liver cell damage, GGT is a sensitive marker for biliary obstruction or irritation. Monitoring this enzyme helps clinicians differentiate between hepatocellular injury and disorders of the bile duct system.

86. (C) Creatinine
Creatinine is an endogenous byproduct of muscle metabolism that is produced at a remarkably constant rate. It is freely filtered by the glomerulus and is neither reabsorbed nor significantly secreted by the renal tubules. These characteristics make it a practical and reliable standard for estimating the glomerular filtration rate in a clinical setting. By measuring serum creatinine levels, veterinarians can assess the overall health and functional capacity of the kidneys.

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87. (C) III and IV
Routine urine biochemistry provides important insights into an animal's metabolic and renal status. Normal specific gravity indicates the kidney's ability to concentrate urine, and proteinuria is often a sign of glomerular disease. However, ketonuria is generally considered pathological in non-ruminants, often indicating starvation or diabetes. Furthermore, glycosuria does not always imply diabetes, as it can occur due to renal tubular defects or extreme stress-induced hyperglycemia.

88. (A) Capture method and sedation protocols
The interpretation of hematological data in wild animals must account for the significant physiological impact of the capture process. Different methods, such as physical pursuit or chemical immobilization, can induce rapid shifts in blood parameters due to stress and splenic contraction. Sedation protocols also influence cardiovascular and metabolic functions. Therefore, clinicians must consider these contextual factors when comparing patient results against established reference ranges to ensure accurate diagnosis.

89. (B) Lactic acid
Capture myopathy is a severe condition triggered by the extreme physical exertion and stress of pursuit in wild animals. During this period, the muscles rely heavily on anaerobic metabolism,

leading to a massive accumulation of lactic acid. This localized buildup causes muscle cell damage and systemic metabolic acidosis. The resulting pathobiochemical changes can lead to organ failure and death, making it a critical concern in wildlife management and veterinary medicine.

90. (B) Type 2 Diabetes
Diabetes mellitus in captive non-human primates is biochemically and pathologically very similar to human Type 2 diabetes. It is characterized by progressive insulin resistance, often associated with obesity and a sedentary lifestyle in a captive environment. Affected individuals exhibit chronic hyperglycemia and initially high insulin levels that eventually decline as beta-cell function fails. This similarity makes primates valuable models for studying the pathogenesis and treatment of this metabolic disease.

91. (A) Water
Cytochrome P450 enzymes are classified as monooxygenases because they incorporate one atom from molecular oxygen into a substrate molecule. During this catalytic process, the second atom of oxygen is reduced by electrons provided by NADPH. This reaction results in the formation of a water molecule as a byproduct. This mechanism allows the enzyme to add a polar hydroxyl group to various xenobiotics, enhancing their reactivity and solubility for further metabolism.

92. (B) I, II and IV
Phase II xenobiotic detoxification involves the conjugation of toxic metabolites with endogenous polar molecules to facilitate their excretion. The major pathways include glucuronidation, sulfation, and glutathione conjugation. These reactions significantly increase the water solubility of the compounds. Hydrolysis and oxidation are primarily Phase I reactions, which serve to prepare the toxins by introducing functional groups rather than completing the detoxification process through conjugation with bulky polar groups.

93. (D) Hematocrit
Dehydration results in a significant loss of water from the plasma compartment, leading to a reduction in total blood volume. Because the number of erythrocytes remains the same while the plasma volume decreases, the proportion of cells relative to the total volume increases. This physiological shift causes a relative elevation in the hematocrit value. This increase, often accompanied by elevated total protein levels, is a classic clinical indicator of dehydration in domestic animals.

94. (C) Glucose-6-phosphate
The hexose monophosphate pathway is an alternative route for glucose metabolism that produces NADPH and pentose sugars. The pathway begins with the conversion of glucose-6-phosphate by the enzyme glucose-6-phosphate dehydrogenase. Therefore, the continuous operation of this pathway is strictly dependent on the availability of glucose-6-phosphate as the starting substrate. This molecule is derived from the first step of glycolysis, linking these two important metabolic processes within the cell.

95. (B) Arachidonic acid
Platelet activation involves a complex signaling cascade that is initiated when the platelet encounters vascular damage. One of the key steps is the activation of phospholipase enzymes, which hydrolyze membrane phospholipids to release arachidonic acid. This fatty acid serves as the essential precursor for the synthesis of thromboxane A_2. Thromboxane A_2 is a powerful mediator that promotes further platelet aggregation and vasoconstriction, ensuring the rapid formation of a stable blood clot.

96. (D) Gamma globulin
Plasma proteins are separated into distinct fractions during electrophoresis based on their physical properties. The gamma globulin fraction is primarily composed of immunoglobulins, which are the antibodies produced by plasma cells. These proteins are essential for the humoral immune system, as they specifically recognize and bind to foreign antigens. An increase in the gamma globulin fraction is often a clinical indicator of chronic infection, inflammation, or certain plasma cell malignancies.

97. (A) Both A and R are true and R is the correct explanation of A.
Fetal hemoglobin has a higher affinity for oxygen than adult hemoglobin, which is essential for oxygen transfer across the placenta. This difference is due to the structure of fetal hemoglobin, which does not bind 2,3-bisphosphoglycerate as strongly as adult hemoglobin. Since 2,3-BPG normally functions to stabilize the deoxygenated

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form and reduce affinity, its reduced binding to fetal hemoglobin ensures that the fetus can effectively compete for oxygen in the maternal blood.

98. (C) Respiratory acidosis
Respiratory acidosis is an acid-base disorder caused by the accumulation of carbon dioxide in the blood, usually due to hypoventilation. According to the bicarbonate buffer system, elevated pCO_2 leads to an increase in carbonic acid and hydrogen ions, resulting in a low blood pH. This condition is commonly seen in animals with lung disease or those undergoing anesthesia. The body responds by retaining bicarbonate through the kidneys to compensate for the acidity.

99. (A) Phosphate
Titratable acidity is a measure of the amount of hydrogen ions excreted in the urine that are bound to buffers other than ammonia. The primary molecular species involved in this process is inorganic phosphate. As hydrogen ions are secreted into the renal tubules, they react with monohydrogen phosphate to form dihydrogen phosphate. Measuring this acidity provides important information about the kidney's ability to excrete metabolic acids and maintain systemic acid-base balance.

100. (D) Calmodulin
Smooth muscle lacks the troponin complex found in skeletal and cardiac muscles. Instead, the regulation of contraction is mediated by the protein calmodulin. When intracellular calcium levels rise, calcium binds to calmodulin, and this complex activates myosin light-chain kinase. This enzyme then phosphorylates the myosin heads, allowing them to interact with actin and initiate contraction. This biochemical mechanism allows smooth muscle to maintain sustained, slow contractions in various internal organs.

101. (B) Providing high tensile strength
Collagen fibers are the primary structural components of connective tissues, and their strength is essential for maintaining tissue integrity. This strength is largely derived from the extensive cross-linking between individual collagen molecules. These covalent bonds stabilize the triple helical structures and link them into larger, organized fibrils. Without this cross-linking, the fibers would lack the necessary tensile strength to resist mechanical forces, leading to tissue fragility and systemic structural failures.

102. (B) P-3, Q-4, R-1, S-2
Metabolic pathways are categorized by their chemical objectives regarding carbohydrates and lipids. Glycolysis involves the breakdown of glucose into pyruvate to generate energy. Gluconeogenesis refers to the synthesis of glucose from non-carbohydrate precursors like lactate. Lipolysis is the biochemical breakdown of triglycerides into fatty acids and glycerol. Lipogenesis is the metabolic process that synthesizes new fatty acids for storage, ensuring energy balance within the organism.

103. (D) C-terminal telopeptide (CTX)
C-terminal telopeptide is a fragment of Type I collagen that is released into the blood during bone resorption. Because Type I collagen is the primary component of the organic bone matrix, the measurement of CTX provides a specific and sensitive indicator of osteoclast activity. This systemic marker is commonly used in clinical settings to monitor the rate of bone mineral breakdown and to evaluate the effectiveness of treatments for metabolic bone diseases.

104. (A) Acetylcholine
Acetylcholine is a major neurotransmitter at the neuromuscular junction and within the autonomic nervous system. It is synthesized within the presynaptic nerve terminal through a reaction between acetyl-CoA and choline. This synthesis is catalyzed by the specific enzyme choline acetyltransferase. Once produced, the neurotransmitter is stored in vesicles until a nerve impulse triggers its release. Its rapid synthesis is essential for maintaining continuous synaptic transmission during periods of high activity.

105. (B) cAMP
During periods of fasting or stress, hormones like epinephrine bind to receptors on adipocytes, leading to the activation of adenylate cyclase. This enzyme increases the intracellular concentration of cyclic AMP. High levels of cAMP then activate protein kinase A, which phosphorylates and activates hormone-sensitive lipase. This signaling cascade is the primary mechanism for stimulating lipolysis, ensuring that stored fatty acids are mobilized to meet the body's energy requirements.

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122. (B) T-state (tense)
Hemoglobin exists in two primary conformational states that differ in their affinity for oxygen. The T-state, or tense state, has a lower affinity and is stabilized by allosteric regulators like protons and carbon dioxide. In metabolically active tissues where CO_2 levels are high, hemoglobin undergoes a shift toward the T-state. This conformational change facilitates the release of oxygen, ensuring that the tissues receive an adequate supply for aerobic respiration while promoting the transport of CO_2 away.

123. (A) The negative logarithm of Ka (pKa)
The Henderson-Hasselbalch equation defines the relationship between the pH of a buffer solution and the properties of the weak acid it contains. According to the equation, a buffer system is most effective at resisting changes in pH when the concentration of the weak acid equals the concentration of its conjugate base. Mathematically, this occurs when the pH is exactly equal to the pKa of the acid. Maintaining physiological pH relies on buffers operating within this optimal range.

124. (C) Na^+/H+ antiporter
Bicarbonate reclamation in the proximal convoluted tubule is a critical process for maintaining systemic acid-base balance. This reclamation is driven by the active secretion of hydrogen ions into the tubular lumen. The primary mechanism for this secretion is the sodium-hydrogen antiporter located on the apical membrane. By exchanging intracellular hydrogen ions for luminal sodium ions, the tubule facilitates the conversion of filtered bicarbonate into carbon dioxide, which can then be reabsorbed into the tubular cells.

125. (D) Aerobic oxidative phosphorylation
Smooth muscle tissue is specialized for maintaining prolonged, tonic contractions in various organs, such as the walls of the gastrointestinal tract and blood vessels. These sustained contractions require a continuous and efficient supply of ATP. Smooth muscle cells meet these high energy demands predominantly through aerobic oxidative phosphorylation within their mitochondria. This metabolic pathway provides a much higher yield of ATP per glucose molecule than anaerobic glycolysis, supporting the long-term functional activity of these tissues.

126. (C) Glycosaminoglycans (GAGs)
Proteoglycans are massive molecules found in the extracellular matrix that play vital roles in tissue structure and hydration. They consist of a central core protein to which multiple long, unbranched polysaccharide chains are covalently attached. These chains, known as glycosaminoglycans, are composed of repeating disaccharide units. Because GAGs are highly negatively charged, they attract large amounts of water and cations, providing the matrix with significant osmotic pressure and resistance to compressive forces in connective tissues.

127. (B) Growth hormone
Bone development and maintenance are regulated by a complex interplay of systemic hormones. Growth hormone, secreted by the anterior pituitary gland, plays a fundamental role by stimulating osteoblasts to produce the organic osteoid matrix. It also coordinates the subsequent mineralization process and promotes the overall growth of bone tissue during development. By influencing the activity of both osteoblasts and chondrocytes, growth hormone ensures that the skeleton achieves its proper size and structural integrity.

128. (D) Glucose
The brain has high metabolic activity and requires a constant supply of energy to maintain nerve signal transmission. Under normal physiological conditions, neurons exhibit an absolute dependency on glucose as their primary fuel source. Glucose is transported across the blood-brain barrier and metabolized through glycolysis and oxidative phosphorylation to generate ATP. Because the brain has very limited stores of glycogen and cannot utilize fatty acids, a steady level of blood glucose is critical for normal neurological function.

129. (A) ATP
Brown adipose tissue is a specialized site for non-shivering thermogenesis, particularly in neonates and hibernating animals. This process is mediated by thermogenin, or uncoupling protein-1, which is located in the inner mitochondrial membrane. Thermogenin allows protons to bypass ATP synthase and flow back into the matrix. This uncoupling of oxidative phosphorylation means that the energy stored in the proton gradient is released as heat rather than being used to

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114. (C) Lymphocytes
The physiological stress response in wild animals involves the prolonged release of cortisol from the adrenal glands. High concentrations of this glucocorticoid hormone have a powerful immunosuppressive effect. Cortisol directly induces apoptosis, or programmed cell death, in lymphocyte populations. By reducing the number of functional T and B cells, stress significantly impairs the animal's ability to mount an effective immune response, increasing its susceptibility to opportunistic infections and other health complications.

115. (A) Myelin sheaths
Leukoencephalomyelopathy is a progressive neurological disease documented in cheetahs that is characterized by the degeneration of white matter tracts. The fundamental pathobiochemical feature of this disorder is the breakdown and loss of the myelin sheaths that insulate nerve fibers. As the myelin degenerates, nerve signal transmission is severely impaired, leading to the clinical signs of ataxia and muscle weakness. This condition highlights the importance of myelin integrity for normal central nervous system function.

116. (D) Peptide bond hydrolysis
The Cytochrome P450 monooxygenase system is the primary enzyme family responsible for Phase I xenobiotic metabolism. These enzymes catalyze a wide range of reactions, including N-dealkylation, aromatic hydroxylation, and epoxidation, all of which typically involve the addition of oxygen or the removal of alkyl groups. However, peptide bond hydrolysis is a reaction mediated by protease enzymes rather than the P450 system. This distinction is important for understanding the different pathways of biochemical degradation.

117. (B) High molecular weight
The elimination of xenobiotics and their metabolites occurs through various routes, with biliary excretion serving as a primary pathway for certain compounds. One of the main factors determining whether a substance is excreted in the bile is its molecular size. Compounds with a relatively high molecular weight, typically exceeding 300 to 500 Daltons, are more likely to be actively transported into the bile by hepatocytes. This route is essential for clearing large, polar conjugates from the body.

118. (C) MCV
The Mean Corpuscular Volume is a standard hematological index that calculates the average volume of a single circulating erythrocyte. It is determined by dividing the hematocrit by the total red blood cell count. MCV is a critical parameter for classifying anemias as microcytic, normocytic, or macrocytic. This information helps clinicians identify the underlying cause of a reduction in red cell mass, such as iron deficiency or vitamin B_{12} malabsorption.

119. (D) Bisphosphoglycerate mutase
The Rapoport-Luebering shunt is a specialized metabolic pathway in erythrocytes that produces 2,3-bisphosphoglycerate. This shunt requires the activity of bisphosphoglycerate mutase, an enzyme that is uniquely expressed in high levels within red blood cells. It converts 1,3-bisphosphoglycerate into 2,3-BPG, which then acts as a crucial allosteric regulator of hemoglobin's oxygen affinity. By controlling the levels of this molecule, the erythrocyte can modulate oxygen delivery to tissues according to metabolic needs.

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120. (A) Lysosomal hydrolytic enzymes
During the process of phagocytosis, a macrophage engulfs a pathogen into a specialized vesicle called a phagosome. To destroy the microorganism, the phagosome must fuse with a lysosome to form a phagolysosome. This fusion process releases a potent mixture of hydrolytic enzymes and acidic substances directly onto the pathogen. These enzymes, including proteases and nucleases, break down the structural components of the microorganism, ensuring its complete destruction and the safe removal of debris.

121. (B) Chronic systemic infection
The Albumin:Globulin ratio is a clinical indicator that often changes during chronic disease states. In cases of chronic systemic infection, the immune system is continuously stimulated to produce high levels of immunoglobulins, which are found in the globulin fraction. Simultaneously, the liver may decrease albumin production as part of the acute phase response. These combined changes result in an inverted A:G ratio, where the concentration of globulins exceeds that of albumin, signaling a prolonged inflammatory process.

153. (B) Apical plasma membrane
Milk lipid synthesis and secretion in the mammary gland involves a unique process of fat globule formation. After synthesis, lipid droplets migrate to the apical region of the mammary epithelial cell. As they are secreted into the alveolar lumen, the droplets are enveloped by a portion of the cell's apical plasma membrane. this result in the formation of the milk fat globule membrane, which stabilizes the lipid emulsion and provides essential proteins and phospholipids that are important for the neonate's nutrition.

154. (B) Microcytic hypochromic anemia
Iron is an essential component of heme, which is necessary for the synthesis of functional hemoglobin. When iron levels are deficient, the bone marrow produces fewer red blood cells, and those that are formed contain less hemoglobin. Consequently, the circulating erythrocytes are smaller than normal and appear pale under a microscope. This condition is clinically classified as microcytic hypochromic anemia. It is a common hematological finding in animals with chronic blood loss or insufficient dietary iron intake, leading to reduced oxygen-carrying capacity.

155. (A) Kidney
The activation of Vitamin D involves a two-step hydroxylation process that begins in the liver. However, the final and most critical step, which produces the potent hormonal form calcitriol, occurs in the kidney. The enzyme 1-alpha-hydroxylase converts 25-hydroxycholecalciferol into 1,25-dihydroxycholecalciferol. This reaction is tightly regulated by parathyroid hormone and systemic mineral levels. Calcitriol then travels to target tissues, such as the intestine and bone, to coordinate calcium absorption and maintain mineral homeostasis throughout the body.

156. (C) Extravascular or intravascular hemolysis
Bilirubin is a byproduct of hemoglobin degradation, and its concentration in the blood is a key indicator of hepatic and hematological health. An increase in unconjugated bilirubin, in the absence of elevated liver enzymes, suggests that the liver is functionally healthy but is being overwhelmed by a massive load of heme. This pattern is characteristic of hemolytic conditions where erythrocytes are destroyed at an accelerated rate. Because the conjugation process cannot keep pace with the bilirubin production, unconjugated levels rise significantly.

157. (D) Urine flow rate
The renal clearance of a marker is used to calculate the glomerular filtration rate according to a specific mathematical formula. This formula requires the concentration of the marker in the urine, its concentration in the plasma, and the rate at which urine is produced. The urine flow rate is essential for determining the total amount of the marker excreted over a specific time period. By combining these three parameters, clinicians can accurately assess the kidney's ability to filter the blood and identify renal dysfunction.

158. (C) Glucose
Urinalysis is a fundamental diagnostic tool that provides information about renal and metabolic function. In healthy mammals, glucose is completely reabsorbed by the proximal tubules after filtration, meaning it should be virtually absent from the urine. The presence of significant quantities of glucose, or glycosuria, is an abnormal finding that typically indicates hyperglycemia or a defect in tubular reabsorption. While urea, creatinine, and uric acid are normal metabolic waste products excreted in the urine, glucose is an essential nutrient that is normally conserved.

159. (B) Hematocrit
The physiological stress of pursuit and capture in wild ungulates triggers the release of catecholamines, which stimulate a rapid contraction of the spleen. The spleen serves as a reservoir for concentrated red blood cells, and its contraction forces these cells into the systemic circulation. This results in a sudden increase in the total number of circulating erythrocytes relative to the plasma volume. Consequently, the hematocrit value rises artifactually, providing a measurable indicator of the animal's acute stress response during the immobilization process.

160. (D) CK-MM
Creatine kinase is an enzyme found in various tissues, and its molecular structure differs depending on its origin. The CK-MM isoform is the specific type found almost exclusively in skeletal muscle. During the muscle damage associated with capture myopathy, skeletal muscle cells rupture and release their internal enzymes into the blood. Therefore, the measurement of the CK-MM isoform provides the most definitive

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synthesize ATP, providing a direct source of warmth.

130. (C) Progesterone
The transition from pregnancy to lactation involves significant hormonal changes. During pregnancy, high levels of progesterone inhibit the final stages of mammary gland development and protein synthesis. The precipitous drop in circulating progesterone that occurs just before parturition removes this inhibitory effect. This hormonal shift allows prolactin and other lactogenic hormones to stimulate the mammary alveolar cells, initiating the production of milk proteins and the onset of lactogenesis in the mother.

131. (A) Generation of free radicals
Iron is an essential element, but in excess, it can be highly toxic to cells. When iron accumulates beyond the body's storage capacity, it can participate in the Fenton reaction, which produces highly reactive hydroxyl radicals. These free radicals cause significant oxidative damage to cellular membranes, proteins, and DNA, leading to tissue injury and organ failure, a condition known as hemochromatosis. The generation of these reactive species is the fundamental mechanism driving the pathobiochemistry of iron overload.

132. (D) Parathyroid hormone (PTH)
Phosphorus homeostasis is closely regulated alongside calcium through the actions of several hormones. Parathyroid hormone is released in response to low blood calcium, but it also has a significant effect on phosphate levels. PTH acts on the renal tubules to inhibit the reabsorption of filtered phosphate, thereby increasing its excretion in the urine. This phosphaturic effect is essential for preventing the accumulation of excess phosphate as the body mobilizes calcium from the bones into the circulation.

133. (B) Horses and ruminants
The diagnostic utility of liver enzymes varies significantly between different animal species. In dogs and cats, Alanine Aminotransferase is a highly specific marker for hepatocellular damage because it is concentrated within liver cells. However, in horses and ruminants, the activity of ALT in the liver is relatively low. In these species, the enzyme is not a reliable indicator of hepatic disease, and clinicians must rely on other markers, such as Sorbitol Dehydrogenase, to assess liver health.

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134. (C) Inulin
The renal clearance of a substance provides a mathematical estimate of the glomerular filtration rate. Inulin, an exogenous polysaccharide, is considered the gold standard for this measurement because it is freely filtered by the glomerulus and is neither reabsorbed nor secreted by the renal tubules. By administering inulin and measuring its concentration in the blood and urine over time, researchers can precisely determine the GFR, providing an accurate assessment of the functional mass of the kidneys.

135. (D) Mildly acidic
The pH of an animal's urine is strongly influenced by its dietary intake and the resulting metabolic byproducts. Carnivores consume diets that are high in protein and sulfur-containing amino acids. The metabolism of these nutrients produces non-volatile acids that must be excreted by the kidneys. Consequently, the urine of strict carnivores is typically mildly acidic. In contrast, herbivores, which consume plant-based diets rich in organic anions, generally produce urine that is more alkaline.

136. (A) Plasma volume
During acute stress and intense pursuit, wild animals experience significant physiological fluid shifts as part of the fight-or-flight response. One of the primary changes is a contraction of the plasma volume. This occurs as fluid moves from the vascular compartment into the interstitial space and cells. Simultaneously, the contraction of the spleen releases concentrated erythrocytes into the circulation. These combined effects lead to a relative hemoconcentration, which is a common finding in stressed wildlife during capture.

137. (B) Myoglobinuria (dark brown urine)
Capture myopathy involves severe muscle cell damage known as rhabdomyolysis. When muscle fibers rupture, they release their contents into the systemic circulation, including the oxygen-binding protein myoglobin. Because myoglobin is a small molecule, it is filtered by the kidneys and excreted in the urine. The presence of myoglobin imparts a distinct dark brown or tea-colored appearance to the urine. This myoglobinuria

is a definitive pathobiochemical indicator of advanced muscle injury in wild ungulates.

138. (B) Insulin levels (initially)
The biochemical profile of a non-human primate with developing Type 2 diabetes is characterized by chronic hyperglycemia. In the early stages of the disease, the body attempts to compensate for insulin resistance by increasing the production of insulin from the pancreatic beta cells. This results in elevated circulating insulin levels alongside high blood glucose. However, as the disease progresses, the beta cells eventually become exhausted, and insulin production declines, leading to a state of relative insulin deficiency.

139. (A) Introducing a polar functional group
Phase I metabolism represents the initial stage of xenobiotic detoxification in the body. The primary chemical objective of these reactions is to introduce or expose a polar functional group, such as a hydroxyl, amino, or carboxyl group, on the target molecule. This modification increases the water solubility of the toxin and, more importantly, provides a site for subsequent Phase II conjugation reactions. These changes are essential for preparing various foreign compounds for efficient elimination from the system.

140. (C) Water solubility
Glucuronidation is a critical Phase II detoxification pathway that involves the attachment of a glucuronic acid moiety to a xenobiotic. Because glucuronic acid is highly polar and ionized at physiological pH, its conjugation significantly increases the water solubility of the resulting metabolite. This change reduces the compound's ability to cross cell membranes and prevents its reabsorption in the renal tubules. Consequently, the modified toxin is effectively trapped in the urine or bile, facilitating its rapid excretion from the body.

141. (D) Chromium-51
Estimating total blood volume can be achieved using isotope dilution techniques, which involve labeling red blood cells. Chromium-51 is the most commonly used radioisotope for this purpose because it binds firmly to the hemoglobin within the erythrocytes. By injecting a known volume of labeled cells and measuring the radioactivity in a blood sample after thorough mixing, clinicians can calculate the total red cell mass. This value, combined with the hematocrit, allows for a precise determination of total blood volume.

142. (C) Heinz bodies
The hexose monophosphate pathway is essential for maintaining reduced glutathione, which protects hemoglobin from oxidative damage. If this pathway fails, reactive oxygen species can cause the cross-linking and precipitation of hemoglobin molecules. These insoluble precipitates form distinct inclusions within the erythrocyte known as Heinz bodies. Their presence is a hallmark of oxidative injury and can be visualized using specialized stains. Heinz bodies impair the flexibility of the red cell, leading to its premature destruction in the spleen.

143. (B) ADP and Serotonin
Platelet activation is an essential process for hemostasis, involving the release of mediators from specialized internal granules. Dense granules are particularly important because they contain high concentrations of ADP and serotonin. Once released, ADP binds to specific receptors on nearby platelets, triggering a potent amplification of the activation signal. Serotonin acts as a vasoconstrictor and further promotes aggregation. Together, these molecules ensure that a sufficient number of platelets are recruited to the site of vascular injury.

144. (D) Electrophoresis
Electrophoresis is a standard laboratory technique used to separate plasma proteins based on their physical and chemical properties. By applying an electrical field to a sample, proteins migrate through a medium at different rates depending on their net charge and molecular mass. This process resolves the plasma into several distinct fractions, including albumin and various globulins. Clinicians use the resulting electrophoretic pattern to identify abnormalities in protein concentrations that may indicate underlying inflammation, liver disease, or immune disorders.

145. (C) 250 times
Carbon monoxide is an extremely toxic gas because it competes with oxygen for the same binding site on the hemoglobin molecule. Hemoglobin's affinity for carbon monoxide is approximately 250 times greater than its affinity for oxygen. This means that even at low

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concentrations, carbon monoxide can displace oxygen and form stable carboxyhemoglobin. This binding not only reduces the oxygen-carrying capacity of the blood but also prevents the remaining oxygen from being released to the tissues, leading to systemic hypoxia.

146. (C) Partial pressure of CO_2 (pCO_2)
In the bicarbonate buffering system, carbon dioxide exists in a dynamic equilibrium with carbonic acid and bicarbonate. According to Henry's Law, the amount of carbon dioxide that dissolves in the plasma is directly proportional to its partial pressure in the gaseous phase. Therefore, the physiological concentration of dissolved CO_2 is calculated by multiplying the pCO_2 by its solubility coefficient. This relationship is fundamental to the Henderson-Hasselbalch equation and is used clinically to assess the respiratory component of acid-base balance.

147. (A) Phosphate
The kidney's ability to excrete metabolic acids relies on the secretion of hydrogen ions and their subsequent capture by urinary buffers. While several systems are involved, the phosphate buffer system is the primary contributor to titratable acidity. As hydrogen ions enter the renal tubules, they react with monohydrogen phosphate to form dihydrogen phosphate. This reaction allows the body to eliminate significant amounts of acid while conserving other essential ions, ensuring that the urine reaches a maximum state of acidification.

148. (D) Mitochondria
Cardiac muscle is a highly active tissue that must contract continuously to maintain circulation throughout the animal's life. This constant work requires a massive and steady supply of ATP. To meet this demand, cardiac myocytes possess an exceptionally high concentration of mitochondria, which occupy a significant portion of the cell's volume. These organelles perform aerobic oxidative phosphorylation, providing a high yield of energy from substrates like fatty acids and glucose, ensuring that the heart never fatigues during normal function.

149. (B) Vitamin C
The structural integrity of collagen fibers depends on the post-translational modification of proline and lysine residues. The enzymes responsible for these hydroxylation reactions require Vitamin C as a necessary cofactor. Hydroxyproline and hydroxylysine are essential for the formation of stable hydrogen bonds that hold the collagen triple helix together. A deficiency in Vitamin C prevents these modifications, leading to the production of weak and defective collagen, which manifests clinically as the connective tissue disorder known as scurvy.

150. (C) Hydrochloric acid
Osteoclasts are specialized cells responsible for the resorption of bone tissue during remodeling and mineral mobilization. To dissolve the inorganic hydroxyapatite crystals, these cells create a sealed acidic environment against the bone surface. They utilize a proton pump to actively secrete large amounts of hydrogen ions and chloride ions, effectively producing hydrochloric acid within this compartment. This localized drop in pH dissolves the bone mineral, releasing calcium and phosphate into the circulation while allowing proteases to degrade the organic matrix.

151. (D) Gangliosides
Gangliosides are a specialized and complex class of glycosphingolipids found in high concentrations within the grey matter of the brain. They consist of a ceramide backbone attached to an oligosaccharide chain that contains one or more residues of N-acetylneuraminic acid, also known as sialic acid. These molecules are essential for cell-to-cell recognition, signaling, and the overall structural integrity of neuronal membranes. Abnormalities in ganglioside metabolism are associated with various severe neurodegenerative disorders in both animals and humans.

152. (A) cAMP
Insulin is the primary anabolic hormone that regulates lipid metabolism by promoting energy storage. In white adipose tissue, insulin powerfully suppresses lipolysis through a signaling cascade that activates phosphodiesterase. This enzyme directly degrades cyclic AMP, thereby reducing its intracellular concentration. By lowering cAMP levels, insulin prevents the activation of protein kinase A and hormone-sensitive lipase. This action effectively stops the mobilization of fatty acids and promotes the synthesis of triglycerides within the adipocyte during the fed state.

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106. (B) Micelles
Caseins are the primary proteins in milk and are unique in their ability to transport large amounts of calcium and phosphate. They achieve this by forming large, stable complexes known as micelles. These micelles consist of thousands of casein molecules held together by hydrophobic interactions and calcium phosphate bridges. This structural form ensures that the essential minerals remain in suspension and are easily delivered to the neonate for bone growth and development.

107. (A) Both A and R are true and R is the correct explanation of A.
Iodine is an essential trace element, but excessive intake can be toxic. However, iodine toxicity is relatively rare in most livestock species compared to deficiency. This is because the mammalian kidney possesses a high capacity to rapidly excrete excess dietary iodide through the urine. This efficient elimination mechanism prevents the accumulation of toxic levels in the blood and tissues, protecting the animal from the adverse effects of iodine overexposure.

108. (C) ATP
Phosphorus is a fundamental component of various biological molecules, including nucleic acids and phospholipids. Most importantly, it is essential for the synthesis of adenosine triphosphate, the primary energy currency of the cell. Severe hypophosphatemia restricts the availability of inorganic phosphate, which directly impairs the production of ATP. This energy deficit leads to widespread cellular dysfunction, affecting muscle contraction, nerve conduction, and various other vital metabolic processes in the animal.

109. (D) Excessive erythrocyte hemolysis
Bilirubin is produced from the breakdown of hemoglobin in senescent erythrocytes. Normally, the liver conjugates this bilirubin to make it water-soluble for excretion. However, if there is a massive increase in erythrocyte destruction, the liver's capacity to conjugate the bilirubin may be exceeded. This results in a significant accumulation of unconjugated, or indirect, bilirubin in the circulation. Therefore, elevated unconjugated bilirubin is a hallmark indicator of extravascular or intravascular hemolytic conditions.

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110. (C) Urea nitrogen (BUN)
Blood Urea Nitrogen is a standard marker for assessing renal function, but its concentration is also dependent on hepatic activity. Urea is synthesized in the liver through the urea cycle as a means to detoxify ammonia produced during protein metabolism. If liver function is severely impaired, urea synthesis decreases, potentially masking underlying renal disease. Therefore, BUN must be interpreted with an understanding of both the kidney's filtration capacity and the liver's synthetic ability.

111. (B) Albumin
Proteinuria refers to the presence of abnormal amounts of protein in the urine. While small amounts of certain proteins can be normal, significant proteinuria is usually indicative of glomerular damage. Albumin is the most common protein found in pathological urine because it is the most abundant plasma protein and its loss through the glomerular filter is a sensitive indicator of basement membrane dysfunction. Monitoring albuminuria helps clinicians diagnose and track the progression of various renal diseases.

112. (A) P-2, Q-4, R-1, S-3
Clinical enzymology utilizes specific enzymes as biomarkers for organ damage. ALT is primarily found in hepatocytes and indicates necrosis when elevated. GGT is a sensitive marker for cholestasis or biliary tract disorders. Creatine kinase is highly concentrated in muscle tissue and rises significantly following muscle injury. Amylase is produced by the pancreas and its elevation in the blood is a classic indicator of pancreatitis. Matching these enzymes to their corresponding pathologies is essential for accurate diagnosis.

113. (A) Acute hemolytic reaction
Blood transfusions in wild animals carry significant risks due to the diversity of blood group antigens. If an animal receives blood that is incompatible, its immune system will recognize the foreign erythrocytes and mount a rapid attack. This acute hemolytic reaction leads to the destruction of the transfused cells, releasing hemoglobin and toxic byproducts into the blood. This can result in systemic shock and death, making pre-transfusion typing and cross-matching critical for wildlife medicine.

biochemical evidence of skeletal muscle injury. This marker helps veterinarians diagnose capture myopathy and assess the severity of rhabdomyolysis in wild animals.

161. (A) Diabetic ketoacidosis
Diabetes mellitus in non-human primates often follows a pathobiochemical course that differs from other species. While they suffer from chronic hyperglycemia and insulin resistance, they are less prone to developing diabetic ketoacidosis. Instead, affected primates are more likely to experience a hyperosmolar hyperglycemic state, where extreme elevations in blood glucose lead to severe dehydration and neurological symptoms. This metabolic distinction is important for the clinical management of diabetic primates, as the underlying mechanisms of electrolyte imbalance and fluid loss require specific treatment strategies.

162. (C) NADPH
The Cytochrome P450 monooxygenase system is the primary enzyme family involved in Phase I xenobiotic metabolism in the liver. For these enzymes to catalyze oxidation reactions, they must receive electrons from a specific donor molecule. NADPH serves as the essential coenzyme that provides these electrons. The electrons are transferred through an intermediate enzyme called NADPH-cytochrome P450 reductase before reaching the iron atom in the P450 active site. This flow of electrons is necessary for the activation of molecular oxygen and the subsequent modification of the substrate.

163. (A) Cysteine
Glutathione is a vital tripeptide that serves as a major intracellular antioxidant and a key substrate for Phase II detoxification reactions. It is composed of three amino acids: glutamate, glycine, and cysteine. The cysteine residue is particularly important because it provides the highly reactive sulfhydryl group that is responsible for the molecule's biochemical activity. By forming covalent bonds with electrophilic toxins or donating electrons to neutralize free radicals, glutathione protects cellular components from damage and facilitates the safe excretion of various harmful substances.

164. (D) Leukocytes and platelets
When a blood sample is centrifuged in a microhematocrit tube, the components separate into three distinct layers based on their density. The bottom layer consists of packed erythrocytes, while the top layer is clear plasma. Between these two is a thin, white or grey layer known as the buffy coat. This fraction is composed of the less dense cellular components, specifically leukocytes and platelets. Measuring the thickness of the buffy coat provides a quick, qualitative assessment of the total white blood cell and platelet counts.

165. (B) Cytochrome b5 reductase
Methemoglobin is a form of hemoglobin where the iron atom is in the oxidized ferric state, making it unable to bind oxygen. In healthy erythrocytes, small amounts of methemoglobin are constantly produced by spontaneous oxidation. To maintain normal function, the cell utilizes the enzyme cytochrome b5 reductase, also known as methemoglobin reductase. This enzyme uses NADH to donate electrons and reduce the iron back to the functional ferrous state. This process is essential for ensuring that the blood maintains a high oxygen-carrying capacity.

166. (C) Arginine
Nitric oxide is a versatile signaling molecule that plays a critical role in the immune response and vascular regulation. In activated macrophages, nitric oxide is synthesized through the action of the enzyme inducible nitric oxide synthase. This enzyme catalyzes the conversion of the amino acid arginine into nitric oxide and citrulline. The produced NO is a potent antimicrobial agent that helps the macrophage destroy engulfed pathogens. Its rapid synthesis is a key feature of the inflammatory response during infection or tissue injury.

167. (D) Low molecular weight
Albumin is the most abundant protein in the plasma and is responsible for maintaining approximately eighty percent of the oncotic pressure. While its high concentration is important, its relatively low molecular weight also contributes to its effectiveness. According to Van't Hoff's law, osmotic pressure depends on the number of particles in a solution. Because albumin molecules are smaller than other plasma proteins like globulins, there are more of them per gram of protein. This ensures that albumin exert a powerful force to keep fluid within the vascular compartment.

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168. (A) Oxygen transfer across the placenta
Fetal hemoglobin possesses a higher affinity for oxygen than adult hemoglobin, which is a critical adaptation for development in utero. This higher affinity creates a partial pressure gradient that facilitates the movement of oxygen from the maternal blood across the placental membrane and into the fetal circulation. By effectively outcompeting the maternal hemoglobin for oxygen, the fetal blood ensures that the developing tissues receive an adequate supply. This biochemical difference is essential for supporting the rapid growth and high metabolic demands of the fetus.

169. (B) 1 to 1
The Henderson-Hasselbalch equation relates the pH of a solution to the pKa and the logarithm of the ratio between the conjugate base and the weak acid. According to the properties of logarithms, the log of one is equal to zero. Therefore, when the concentrations of the base and the acid are equal, the log term disappears, and the pH becomes exactly equal to the pKa. This relationship demonstrates that buffer systems are most effective when the acid and its conjugate base are present in a one-to-one ratio.

170. (B) Type A intercalated cells
The final adjustment of urine pH occurs in the collecting duct, where specialized cells regulate the secretion of hydrogen ions and the reabsorption of bicarbonate. Type A intercalated cells are primarily responsible for the active secretion of protons into the tubular lumen during states of acidosis. They utilize H+ ATPases and $H+/K^+$ ATPases on their apical membranes to move hydrogen ions against a significant concentration gradient. This process is essential for the elimination of metabolic acids and the maintenance of systemic acid-base balance.

171. (A) Very rapid, very limited capacity
The creatine phosphate system is the most immediate source of energy for muscle contraction. This biochemical pathway involves a single enzymatic reaction where a high-energy phosphate is transferred from creatine phosphate to ADP. Because it consists of only one step, the regeneration of ATP is extremely rapid, occurring almost instantaneously at the onset of exertion. However, the stores of creatine phosphate in the muscle are very small, meaning the system can only support intense activity for a very short duration before other pathways must take over.

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172. (C) Triple helix
The extraordinary tensile strength of collagen fibers is a direct result of their unique triple helical structure. Each collagen molecule consists of three polypeptide chains that are tightly wound around each other to form a rigid, rod-like structure. This configuration is stabilized by numerous hydrogen bonds between the chains and by the repeating Gly-X-Y amino acid sequence. When these triple helices are bundled together and cross-linked into larger fibrils, they provide connective tissues with the mechanical strength necessary to resist stretching and maintain structural integrity.

173. (D) Extensive calcification
Osteoid is the organic part of the bone matrix that is synthesized by osteoblasts. While it shares some components with other connective tissues, such as Type I collagen, it is uniquely distinguished by its capacity for extensive calcification. During bone formation, inorganic mineral crystals are deposited within the organized osteoid scaffold, a process that is tightly regulated by bone-specific proteins and enzymes. This mineralization transforms the flexible organic matrix into a hard, rigid tissue, providing the skeleton with its characteristic strength and ability to support the weight of the animal.

174. (C) Astrocyte uptake and glutamine conversion
Glutamate is the primary excitatory neurotransmitter in the brain, and its levels in the synaptic cleft must be strictly regulated to prevent excitotoxicity. The primary mechanism for clearing glutamate is its rapid uptake by surrounding glial cells, particularly astrocytes. Once inside the astrocyte, glutamate is converted into the non-toxic amino acid glutamine by the enzyme glutamine synthetase. The glutamine is then released and taken up by the presynaptic neuron, where it is converted back into glutamate for reuse, ensuring an efficient and safe recycling pathway.

175. (B) Neonatal and hibernating mammals
Brown adipose tissue is a specialized site for non-shivering thermogenesis, a process that is vital for survival in specific physiological states. Because neonates have a high surface

area-to-volume ratio and immature shivering mechanisms, they rely heavily on brown fat to maintain body temperature after birth. Hibernating mammals also utilize brown adipose tissue to generate the rapid burst of heat required to wake up from torpor. In these animals, the thermogenic capacity of brown fat is essential for maintaining homeostasis during periods of extreme environmental cold.

176. (D) Alpha-lactalbumin
Lactose synthase is the enzyme complex responsible for the synthesis of lactose within the mammary gland. It consists of two components: galactosyltransferase and the regulatory milk protein alpha-lactalbumin. In most tissues, galactosyltransferase functions in the synthesis of glycoproteins. However, in the mammary gland during lactation, alpha-lactalbumin binds to the enzyme and changes its substrate specificity, allowing it to utilize glucose as an acceptor for galactose. This specialized interaction is the critical biochemical trigger for the large-scale production of lactose in milk.

177. (A) Thyroid gland
The thyroid gland is the primary endocrine organ responsible for the sequestration and utilization of circulating iodine. Follicular cells in the thyroid actively transport iodide from the blood into the gland using a specialized sodium-iodide symporter. This process allows the gland to maintain a concentration of iodine that is much higher than that found in the plasma. The sequestered iodine is then incorporated into the protein thyroglobulin to synthesize the thyroid hormones thyroxine and triiodothyronine, which are essential for regulating metabolism and growth throughout the body.

178. (C) Calcium
Parathyroid hormone plays a central role in maintaining calcium homeostasis by acting on multiple target organs. In the kidney, PTH has a specific effect on the distal convoluted tubule, where it promotes the active reabsorption of filtered calcium ions. By increasing the expression and activity of calcium channels, the hormone ensures that more calcium is returned to the circulation instead of being lost in the urine. This renal action is a key component of the body's response to hypocalcemia, helping to restore normal blood calcium levels.

179. (A) SDH (Sorbitol Dehydrogenase)
In horses and ruminants, the standard liver enzyme ALT has very low activity and is not a useful marker for hepatic disease. Consequently, clinicians rely on sorbitol dehydrogenase as a more sensitive and specific indicator of hepatocellular injury. SDH is primarily found in the liver and is released into the blood following damage to the hepatocytes. Because the enzyme has a short half-life, elevated levels are indicative of active, ongoing liver damage, making it a valuable diagnostic tool for assessing hepatic health in these large animal species.

180. (D) Pre-renal azotemia
Azotemia is an elevation of nitrogenous waste products in the blood, and its cause can be renal or non-renal. A disproportionate increase in BUN relative to serum creatinine is a classic indicator of pre-renal azotemia. This condition is often caused by factors that reduce renal blood flow, such as dehydration or congestive heart failure. In these states, the slowed flow in the tubules allows more urea to be reabsorbed while creatinine clearance remains relatively stable, leading to the characteristic biochemical pattern of elevated BUN with normal or mildly increased creatinine.

181. (A) Nephrotic syndrome
Nephrotic syndrome is a clinical condition resulting from severe damage to the glomerular filtration barrier. It is defined by a distinct triad of symptoms: heavy proteinuria, severe hypoalbuminemia, and generalized edema. As massive amounts of albumin are lost in the urine, the plasma oncotic pressure drops, leading to fluid leakage into the tissues. The liver also increases its synthesis of lipoproteins in a failed attempt to compensate for the protein loss, resulting in hypercholesterolemia. This syndrome is a serious manifestation of various glomerular diseases in animals.

182. (C) Chemical immobilization and physical restraint
Establishing reliable baseline blood biochemistry for wildlife is challenging due to the significant physiological impact of the capture process. Most wild animals must be either physically restrained or chemically immobilized for blood collection, both of which trigger a massive stress response. This response involves the release of catecholamines and cortisol, which

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which allows it to bind calcium ions with high affinity. This reaction is strictly dependent on Vitamin K as a necessary cofactor. Without adequate Vitamin K, osteocalcin remains in an undercarboxylated state and cannot effectively bind to the bone mineral. Consequently, Vitamin K deficiency impairs bone quality and is associated with an increased risk of skeletal abnormalities and reduced mineral density in various mammalian species.

197. (B) Golgi apparatus
Sphingolipids, including cerebrosides and gangliosides, are essential structural components of neuronal membranes. Their synthesis begins with the formation of ceramide in the endoplasmic reticulum. The ceramide is then transported to the Golgi apparatus, where specific glycosyltransferase enzymes add carbohydrate moieties to the ceramide backbone. The Golgi is the primary site for the diversification and final assembly of these complex glycolipids. Once synthesized, the cerebrosides and gangliosides are packaged into vesicles and transported to the plasma membrane, where they play critical roles in cell signaling, recognition, and the overall stability of the nerve tissue.

198. (C) Norepinephrine
Brown adipose tissue is a specialized site for non-shivering thermogenesis, a process that is centrally regulated by the sympathetic nervous system. During exposure to extreme cold, the hypothalamus triggers the release of norepinephrine from sympathetic nerve endings within the brown fat. Norepinephrine binds to beta-adrenergic receptors on the adipocytes, initiating a signaling cascade that increases cAMP levels and activates lipolysis. The released fatty acids then activate thermogenin, leading to the uncoupling of oxidative phosphorylation and the rapid generation of heat, which is essential for maintaining body temperature in neonates and hibernating mammals.

199. (D) Thioesterase II
Milk lipid synthesis in the mammary gland involves the production of fatty acids with unique chain lengths. Unlike other tissues that primarily produce long-chain fatty acids, the mammary gland can synthesize significant amounts of medium-chain fatty acids. This is achieved through the action of a specialized enzyme called thioesterase II. This enzyme interacts with the fatty acid synthase complex and causes the premature release of the growing fatty acid chain once it reaches a medium length. These specific fatty acids are more easily digested by the neonate, providing a concentrated and accessible energy source during the lactation period.

200. (A) Ferroportin
Hepcidin is a key regulatory hormone produced by the liver that controls systemic iron homeostasis. It functions by binding to ferroportin, the only known cellular iron exporter, located on the basolateral membrane of enterocytes and macrophages. This binding triggers the internalization and lysosomal degradation of ferroportin, thereby blocking the release of iron into the blood and lowering circulating iron levels. This mechanism ensures that iron absorption and mobilization are tightly regulated according to the body's needs and storage levels, preventing the accumulation of toxic concentrations while ensuring an adequate supply for hemoglobin synthesis.

201. (B) Osteoclasts
Calcitonin is a hormone produced by the parafollicular cells of the thyroid gland in response to elevations in blood calcium. Its primary physiological effect is to rapidly lower circulating calcium levels by directly inhibiting the activity of osteoclasts. Calcitonin binds to specific G-protein coupled receptors on the surface of these bone-resorbing cells, leading to a decrease in their motility and acid secretion. By stopping the breakdown of the mineralized bone matrix, calcitonin prevents the release of calcium and phosphate into the circulation, acting as a functional antagonist to parathyroid hormone to maintain mineral balance.

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202. (B) Active bone remodeling and growth
Serum Alkaline Phosphatase is a widely used biochemical marker, but its activity must be interpreted in the context of the animal's age. While ALP is produced by the liver and biliary system, a significant isoform is also produced by osteoblasts. In young, growing animals, the high rate of active bone remodeling and longitudinal growth leads to a physiological elevation of the bone-specific ALP isoform in the blood. This increase is a normal finding and does not indicate underlying disease. Monitoring ALP helps clinicians assess bone development and

of the internal actin cytoskeleton. The polymerization of actin filaments allows the platelet to extend its membrane and increase its surface area for attachment and aggregation. This structural change is essential for the formation of a stable platelet plug and for the overall process of hemostasis, ensuring that vascular injuries are effectively sealed to prevent blood loss.

190. (C) Liver
Fibrinogen is a massive, soluble glycoprotein that serves as a critical component of the coagulation cascade. It is synthesized and secreted exclusively by the hepatocytes in the liver. As an acute phase reactant, its production significantly increases during periods of inflammation or tissue injury. In the final stage of blood clotting, the enzyme thrombin converts fibrinogen into insoluble fibrin strands, which form the structural meshwork of a stable blood clot. Monitoring fibrinogen levels provides important information about an animal's clotting ability and the presence of systemic inflammatory processes.

191. (B) Cooperative binding
The oxygen dissociation curve of hemoglobin is sigmoidal due to the principle of cooperative binding. Hemoglobin is a tetramer with four oxygen-binding sites. When the first oxygen molecule binds, it causes a conformational change in the entire protein that increases the affinity of the remaining sites. This means that each subsequent oxygen molecule binds more easily than the previous one. This cooperation allows hemoglobin to be highly saturated in the oxygen-rich environment of the lungs and to release oxygen efficiently in the tissues where the partial pressure is lower.

192. (D) Decreasing oxygen affinity to enhance release
During intense physical exertion, the accumulation of lactic acid and carbon dioxide in the muscles leads to a decrease in the localized blood pH. This acidic environment acts as an allosteric regulator that decreases hemoglobin's affinity for oxygen, a phenomenon known as the Bohr effect. This shift in affinity is physiologically beneficial because it promotes the release of oxygen from hemoglobin to the actively respiring tissues. By ensuring that more oxygen is available for aerobic metabolism during exercise, this mechanism supports sustained muscle activity and helps delay the onset of fatigue.

193. (A) Carbonic anhydrase
The synthesis of new bicarbonate ions in the renal tubules is a fundamental mechanism for maintaining systemic acid-base balance. This process relies on the intracellular enzyme carbonic anhydrase, which catalyzes the rapid hydration of carbon dioxide to form carbonic acid. The carbonic acid then dissociates into hydrogen ions and bicarbonate. The hydrogen ions are secreted into the tubular lumen to be excreted, while the newly formed bicarbonate is transported across the basolateral membrane and into the circulation, replenishing the body's essential alkaline reserves and buffering metabolic acids.

194. (C) Myosin light chain phosphorylation
Smooth muscle contraction is regulated by a biochemical mechanism that is distinct from the troponin-based system in striated muscle. The key regulatory event is the phosphorylation of the myosin light chain. When intracellular calcium levels rise, the calcium-calmodulin complex activates myosin light-chain kinase. This enzyme then transfers a phosphate group to the myosin heads, enabling them to bind to actin and initiate the cross-bridge cycle. This phosphorylation is necessary for contraction to occur, and relaxation is subsequently achieved by the action of myosin light-chain phosphatase, which removes the phosphate group.

195. (A) Water
Proteoglycans are major components of the cartilage matrix that provide the tissue with its unique mechanical properties. These molecules consist of a core protein attached to long glycosaminoglycan chains, which are highly negatively charged. Due to their high charge density, proteoglycans exert a powerful osmotic force that attracts large amounts of water into the matrix. This hydration creates a state of swelling pressure that is resisted by the collagen network. The resulting hydrostatic pressure allows cartilage to withstand significant compressive forces and absorb shocks during joint movement without sustaining structural damage.

196. (D) Vitamin K
Osteocalcin is a non-collagenous protein synthesized by osteoblasts that plays a role in bone mineralization. To function correctly, osteocalcin must undergo a post-translational modification called gamma-carboxylation,

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222. (C) Prolonged digestion and absorption
The digestion of milk in neonates involves a unique process of curd formation in the stomach. When milk is consumed, the enzyme chymosin, also known as rennin, acts on the casein micelles, causing them to precipitate and form a semi-solid curd. This precipitation is further enhanced by the acidic gastric environment and the presence of calcium. The formation of the curd is physiologically beneficial because it slows down gastric emptying. By prolonging the time the milk remains in the stomach, this mechanism ensures more complete enzymatic digestion of the proteins and more efficient absorption of the released nutrients.

223. (B) Ferrous (Fe2+) state
The absorption of dietary iron is a highly regulated process that occurs primarily in the duodenum and proximal jejunum. Most non-heme iron in the diet is in the ferric state, but it must be converted to the ferrous state to be transported into the enterocyte. A specialized reductase enzyme on the apical membrane of the intestinal cells reduces the iron before it is taken up by the divalent metal transporter 1. This requirement for the ferrous state is a critical factor in iron bioavailability, as various dietary factors can influence the reduction and solubility of iron within the intestinal lumen.

224. (D) Intracellular nuclear receptors
Calcitriol, the most potent hormonal form of Vitamin D, functions as a steroid hormone to regulate calcium and phosphate homeostasis. Because it is a lipid-soluble molecule, calcitriol can cross cell membranes and enter the nucleus of its target cells. Once inside, it initiates its physiological effects by binding to specific intracellular nuclear receptors known as Vitamin D receptors. This binding triggers the receptor to act as a transcription factor, modulating the expression of various genes involved in mineral transport and bone metabolism. This genomic action ensures a coordinated and long-lasting response to changes in systemic mineral levels.

225. (A) Serum bile acids
The Bromosulfophthalein clearance test was traditionally used to assess hepatic secretory function, but its use has largely been superseded by the measurement of serum bile acids. Bile acids are synthesized by the liver and undergo an efficient enterohepatic circulation. When liver function or portal blood flow is impaired, the hepatocytes are unable to remove bile acids from the circulation, leading to a significant increase in their serum concentration. Measuring pre- and post-prandial bile acid levels provides a more sensitive and convenient diagnostic indicator of various liver diseases, such as portosystemic shunts and hepatocellular failure, in veterinary clinical practice.

226. (B) Ammonia
Blood Urea Nitrogen is a measurement of the nitrogen contained in urea, which is the primary end product of protein metabolism in mammals. Urea is synthesized in the liver through the urea cycle specifically to detoxify ammonia. Ammonia is produced by the breakdown of amino acids and by bacterial activity in the gut, and it is highly toxic to the nervous system. The liver efficiently converts this ammonia into urea, which is much less toxic and more water-soluble. The produced urea is then released into the blood and eliminated by the kidneys, serving as a critical marker for both hepatic and renal function.

227. (A) Strenuous exercise or stress
Proteinuria is often a sign of renal disease, but it can also occur as a transient, physiological phenomenon in healthy animals. Extreme events such as strenuous exercise, severe stress, or fever can lead to a temporary increase in the amount of protein excreted in the urine. This is likely due to changes in renal blood flow and glomerular permeability triggered by catecholamines or other inflammatory mediators. Physiological proteinuria is typically mild and resolves once the underlying stressor is removed. Clinicians must differentiate this transient condition from persistent, pathological proteinuria when evaluating the results of a routine urinalysis in domestic animals.

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228. (D) Age, sex, and season
Establishing accurate blood biochemistry reference intervals for wild animal populations is complex because these values are influenced by numerous biological and environmental factors. To ensure that the reference ranges are statistically valid and clinically useful, researchers must segregate their data based on the animal's age, sex, and the season of collection. For example, growing juveniles often have higher alkaline phosphatase levels, and reproductive status or

differentiate between skeletal growth and hepatic or biliary disorders.

203. (A) Inulin clearance
The glomerular filtration rate is the best overall measure of renal function. While several methods exist to estimate GFR, the inulin clearance test is considered the most accurate mathematical representation. Inulin is a polysaccharide that is freely filtered and neither reabsorbed nor secreted, making its clearance rate exactly equal to the GFR. However, because inulin is not produced by the body, the test requires a continuous intravenous infusion to maintain a steady plasma concentration. This complexity makes it primarily a research tool rather than a routine clinical procedure, though it remains the physiological gold standard.

204. (C) Urea
Ruminant metabolism is uniquely adapted for the processing of plant-based diets, which results in characteristic urine biochemistry. Because their diet is rich in organic anions, ruminants typically produce alkaline urine. Their nitrogen metabolism is also highly efficient, involving the recycling of urea through the rumen. The urea that is not recycled is excreted by the kidneys. Consequently, normal ruminant urine is rich in urea, reflecting the end product of protein degradation and the animal's ability to maintain nitrogen balance despite the complex fermentation processes occurring in their digestive system.

205. (D) Erythrocyte morphology
Erythrocyte morphology varies significantly across different animal classes. In mammals, mature erythrocytes are unique because they lack a nucleus and most other organelles, which maximizes their space for hemoglobin. In contrast, healthy adult avian and reptilian species possess erythrocytes that are nucleated and ellipsoidal in shape. This fundamental difference is important for clinicians to recognize during hematological evaluations, as the presence of nucleated red cells in a mammalian blood smear is typically a pathological finding indicating intense bone marrow stimulation or disease, whereas in birds and reptiles, it is the normal physiological state.

206. (C) Lactic acid from anaerobic glycolysis
Capture myopathy is a life-threatening condition in wild animals that is characterized by severe metabolic acidosis. During the extreme exertion and stress of pursuit, the animal's muscles quickly exhaust their oxygen supply and shift to anaerobic glycolysis to meet energy demands. This metabolic pathway produces large amounts of lactic acid as a byproduct. The massive systemic release of lactic acid from damaged muscle cells causes a precipitous drop in blood pH. This profound acidosis disrupts cellular function and can lead to multiple organ failure and death, making it the primary pathobiochemical driver of capture-related mortality.

207. (B) Leukoencephalomyelopathy
Leukoencephalomyelopathy is a progressive neurological disorder that has been specifically documented in captive cheetahs. The pathobiochemical hallmark of this disease is the bilateral and symmetrical degeneration of the white matter in the central nervous system, particularly within the spinal cord. This degeneration involves the loss of the myelin sheaths that insulate nerve fibers, leading to impaired signal transmission. Affected cheetahs typically display clinical signs such as progressive ataxia and motor deficits. While the exact cause is still being researched, the condition represents a significant health concern for captive cheetah populations and highlights the vulnerability of their nervous system.

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208. (D) Cytochrome P450 (CYP) superfamily
The Cytochrome P450 superfamily is a massive and diverse group of hemoprotein enzymes that serve as the primary drivers of Phase I xenobiotic metabolism. These enzymes are located in the smooth endoplasmic reticulum, particularly in the liver, and are responsible for catalyzing oxidation reactions on a wide range of foreign compounds. By adding polar functional groups, they increase the reactivity and water solubility of toxins, preparing them for subsequent conjugation and excretion. The functional diversity and broad substrate specificity of the CYP superfamily make it the most critical enzymatic system for the detoxification of drugs and environmental toxins in mammals.

209. (A) Hydrophilic to prevent tubular reabsorption
The ultimate goal of Phase II xenobiotic metabolism is to ensure that toxic compounds are efficiently eliminated from the body. This is achieved by conjugating the compounds with endogenous polar molecules, such as

glucuronic acid or sulfate. These reactions significantly increase the hydrophilicity of the resulting metabolites. Because these large, polar molecules are water-soluble and often ionized at physiological pH, they cannot easily cross the lipid membranes of the renal tubules. This effectively prevents their reabsorption into the blood and ensures that they remain in the urine, facilitating their rapid and complete excretion from the systemic circulation.

210. (C) Mean Corpuscular Hemoglobin Concentration (MCHC)
The Mean Corpuscular Hemoglobin Concentration is a standard hematological index that provides information about the hemoglobin content of erythrocytes. Unlike MCH, which measures the average weight of hemoglobin per cell, MCHC calculates the average concentration of hemoglobin within a specific volume of packed red blood cells. It is determined by dividing the total hemoglobin concentration by the hematocrit. MCHC is an important parameter for diagnosing and classifying anemias, as values outside the normal range can indicate problems with hemoglobin synthesis or changes in erythrocyte volume, helping clinicians identify the underlying cause of the disorder.

211. (A) NAD+
Mammalian erythrocytes rely entirely on anaerobic glycolysis for energy production because they lack mitochondria. In the final step of this pathway, the enzyme lactate dehydrogenase catalyzes the reduction of pyruvate to lactate. This reaction is essential because it simultaneously oxidizes NADH back to NAD+. The continuous availability of NAD+ is required for the earlier steps of glycolysis to proceed. By regenerating this coenzyme, the erythrocyte ensures a steady flow of ATP production, which is necessary for maintaining membrane integrity and ion pumps, despite the absence of aerobic respiration and oxygen utilization by the cell.

212. (D) Hypochlorous acid
During the respiratory burst in activated macrophages, several reactive oxygen species are generated to destroy engulfed pathogens. One of the most potent mediators is hypochlorous acid, which is synthesized through the action of the enzyme myeloperoxidase. This enzyme catalyzes the reaction between hydrogen peroxide and chloride ions. Hypochlorous acid functions as a powerful antimicrobial bleaching agent that causes irreversible damage to the proteins and membranes of microorganisms. This highly effective chemical weapon is a key component of the innate immune system's ability to neutralize infections and clear foreign material from the body's tissues.

213. (D) Beta globulin
C-Reactive Protein is an acute phase reactant that is synthesized by the liver in response to systemic inflammation and tissue injury. During plasma protein electrophoresis, CRP typically migrates within the beta globulin fraction, although its exact position can vary slightly between species. Levels of CRP rise rapidly following the onset of an inflammatory stimulus and fall quickly as the condition resolves. Because of its sensitivity and rapid response, monitoring CRP concentration in the blood is a valuable clinical tool for identifying the presence of inflammation, assessing its severity, and evaluating the animal's response to medical treatment.

214. (C) Carbon dioxide
The Haldane effect describes the reciprocal relationship between the oxygenation of hemoglobin and its ability to transport carbon dioxide. When hemoglobin binds oxygen in the lungs, it undergoes a conformational shift that reduces its affinity for carbon dioxide and protons. Consequently, oxygenated blood has a significantly lower capacity to carry CO_2 compared to deoxygenated blood. this result in the rapid release of carbon dioxide into the alveoli for exhalation. This physiological mechanism ensures that the blood can efficiently load oxygen while simultaneously unloading metabolic waste, optimizing gas exchange at the respiratory surface and maintaining systemic acid-base balance.

215. (D) Hemoglobin
The primary intracellular buffering system within the erythrocyte cytoplasm is provided by the high concentration of hemoglobin. Because hemoglobin is a large protein with numerous amino acid side chains, it possesses many potential binding sites for hydrogen ions. As metabolic acids are produced in the tissues, the deoxygenated form of hemoglobin effectively binds these protons, preventing significant

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changes in intracellular pH. This buffering capacity is essential for maintaining the stability of the cell and for facilitating the transport of carbon dioxide as bicarbonate, ensuring that the erythrocyte can function effectively despite the acidic environment of metabolically active tissues.

216. (A) Monohydrogen phosphate
In the distal nephron, the kidney performs final adjustments to urine pH by secreting hydrogen ions. To ensure that the urine does not become excessively acidic, these ions must be captured by urinary buffers. The primary buffer responsible for forming titratable acidity is monohydrogen phosphate. As hydrogen ions are secreted, they react with monohydrogen phosphate to form dihydrogen phosphate. This reaction effectively traps the acid in the tubular lumen, allowing it to be excreted in the urine. By utilizing this phosphate buffer system, the body can eliminate significant amounts of metabolic acid while preserving systemic bicarbonate levels.

217. (B) Lactate and protons
Muscle fatigue during supramaximal exercise is a complex phenomenon driven by various metabolic changes. As the muscle exceeds its aerobic capacity, it shifts to anaerobic metabolism, leading to a rapid accumulation of lactate and hydrogen ions within the sarcoplasm. The resulting decrease in intracellular pH interferes with several critical processes, including enzyme activity and calcium binding to troponin. This acidic environment inhibits the contractile mechanism and the regeneration of ATP, ultimately resulting in a decline in force production and the onset of fatigue, acting as a protective mechanism to prevent permanent cellular damage from overexertion.

218. (B) Lysine
Elastin is a highly flexible protein in the extracellular matrix that allows tissues to stretch and recoil. This structural resiliency is conferred by a unique network of cross-links known as desmosine. These cross-links are formed through a complex reaction that strictly requires the oxidative deamination of specific lysine residues. The enzyme lysyl oxidase catalyzes this oxidation, producing reactive aldehydes that subsequently condense to form the desmosine structure. By linking four separate elastin polypeptide chains, these cross-links create a stable yet elastic framework that is essential for the function of organs like the lungs and large blood vessels.

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219. (A) Resorption
Bone is a dynamic tissue that undergoes continuous remodeling throughout an animal's life. This process involves a balance between the formation of new bone matrix and the breakdown of old tissue. Consequently, biochemical markers of bone turnover are definitively categorized into two groups: markers of bone formation, which reflect osteoblast activity, and markers of bone resorption, which reflect the activity of osteoclasts. Monitoring these systemic markers in the blood or urine provides clinicians with valuable information about the rate of bone metabolism and helps in the diagnosis and management of various metabolic skeletal disorders in domestic animals.

220. (C) Phosphocholine
Sphingomyelin is a major structural lipid found in the myelin sheaths that insulate nerve fibers. Like all sphingolipids, it is built on a ceramide backbone, which consists of a sphingosine molecule attached to a fatty acid. Sphingomyelin is distinguished by its unique polar head group, which is composed of a phosphocholine moiety. This head group is attached to the primary hydroxyl group of the ceramide. The resulting molecule is essential for maintaining the integrity and electrical insulation of the nerve membrane, ensuring the rapid and efficient transmission of electrical impulses along the axon in the nervous system.

221. (D) Biotin
Lipogenesis is the metabolic pathway responsible for synthesizing new fatty acids from acetyl-CoA. The first and rate-limiting step of this process is catalyzed by the enzyme acetyl-CoA carboxylase, which converts acetyl-CoA into malonyl-CoA. This enzyme stringently requires the vitamin biotin as a necessary cofactor. Biotin serves as a carrier of the carboxyl group, which is transferred to the substrate during the reaction. A deficiency in biotin can impair the body's ability to synthesize lipids, affecting energy storage and the structural integrity of cell membranes, highlighting the importance of this vitamin in mammalian nutrition.

cause rapid shifts in blood glucose, electrolytes, and hematological indices. To obtain accurate reference intervals, researchers must account for these effects and standardized their collection methods to minimize the influence of capture-related stress on the biochemical results.

183. (D) Myoglobin
Capture myopathy is characterized by extreme rhabdomyolysis, which involves the widespread destruction of skeletal muscle cells. This process releases massive amounts of intracellular components into the systemic circulation, including the protein myoglobin. Once in the blood, myoglobin is filtered by the glomeruli and enters the renal tubules. At high concentrations and in an acidic environment, myoglobin is highly nephrotoxic, causing direct damage to the tubular cells and leading to acute renal failure. This secondary organ failure is a major cause of mortality in animals suffering from capture-related muscle injury.

184. (A) Pancreatic islets of Langerhans
The pathogenesis of Type 2 diabetes in captive non-human primates involves the progressive failure of the pancreatic beta cells. A distinct pathobiochemical feature of this condition is the accumulation of amyloid deposits within the islets of Langerhans. These deposits consist of islet amyloid polypeptide, which is co-secreted with insulin. Over time, the amyloid buildup replaces the functional islet tissue and is toxic to the remaining beta cells, directly contributing to the loss of insulin-producing capacity and the development of chronic hyperglycemia in affected individuals.

185. (B) Induction by repetitive xenobiotic exposure
Cytochrome P450 enzymes are highly dynamic and their expression can be significantly influenced by environmental factors. One of the most important characteristics of this enzyme family is its ability to be induced by repetitive exposure to certain xenobiotics. When an animal is continuously exposed to a drug or toxin, the liver responds by increasing the synthesis of the specific P450 isoenzymes responsible for its metabolism. This induction increases the rate of detoxification but can also lead to faster metabolism of other beneficial drugs, a process that is critical for understanding pharmacokinetics.

186. (B) Glutathione conjugation
Glutathione conjugation is a critical Phase II reaction that protects cells from highly reactive electrophilic compounds. These reactive metabolites are often produced during Phase I oxidation and can cause significant damage to DNA and proteins if not neutralized. The enzyme glutathione S-transferase facilitates the binding of the tripeptide glutathione to these toxins. This conjugation not only neutralizes the reactive groups but also significantly increases the water solubility of the compound. This pathway is universally essential for the detoxification of various harmful metabolites and for maintaining cellular integrity.

187. (A) $\text{Total Blood Volume} = \dfrac{\text{Plasma Volume}}{1 - \text{Hematocrit}}$
The estimation of total blood volume is based on the relationship between the volume of plasma and the volume of cells in the circulation. The hematocrit represents the fraction of whole blood occupied by erythrocytes. Therefore, the remaining fraction, represented as one minus the hematocrit, corresponds to the plasma. By measuring the plasma volume using dye dilution and dividing it by this plasma fraction, clinicians can mathematically calculate the total blood volume. This calculation is a fundamental principle for assessing the overall cardiovascular and hydration status of an animal.

188. (C) ATP
The erythrocyte glycolytic pathway involves several steps that generate energy for the cell. The conversion of 1,3-bisphosphoglycerate to 3-phosphoglycerate is catalyzed by the enzyme phosphoglycerate kinase. This reaction is a substrate-level phosphorylation that transfers a high-energy phosphate group to ADP, resulting in the production of one molecule of ATP. This step is the primary source of chemical energy for the erythrocyte, supporting the maintenance of membrane pumps and other essential cellular functions. If this step is bypassed, as in the Rapoport-Luebering shunt, the potential ATP yield is sacrificed.

189. (D) Actin cytoskeleton
Platelet activation involves a dramatic change in the cell's morphology as it transitions from a resting disc to a highly irregular shape with multiple pseudopodia. This transformation is driven by a rapid and extensive reorganization

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seasonal nutritional changes can significantly shift electrolyte and protein concentrations. By accounting for these variables, veterinarians can more accurately interpret the health status of individual wild animals and track the overall wellbeing of the population.

229. (B) Myoglobinuric renal failure states
The immediate treatment of acute capture myopathy in wildlife focuses on aggressive intravenous fluid therapy. This medical intervention is essential to address the massive release of myoglobin from damaged muscle cells. In an acidic environment, myoglobin can precipitate in the renal tubules and cause direct toxic damage, leading to acute renal failure. By providing large volumes of intravenous fluids, clinicians can promote high urine flow and maintain tubular hydration, which helps to dilute the myoglobin and facilitate its safe excretion. This treatment strategy is critical for preventing terminal kidney failure and improving the chances of survival for the affected animal.

230. (C) Glycated hemoglobin (HbA1c)
Managing diabetes mellitus in captive non-human primates requires regular monitoring of blood glucose levels to assess the effectiveness of treatment. However, because blood glucose can fluctuate significantly throughout the day, clinicians also utilize glycated hemoglobin as a definitive marker. HbA1c represents the proportion of hemoglobin that has glucose covalently attached, reflecting the average blood glucose concentration over several weeks. By monitoring HbA1c, researchers can track the long-term progression of the disease and evaluate the animal's glycemic control more accurately than with individual glucose measurements, providing a valuable tool for managing metabolic health in these primate species during captivity.

231. (D) Azo, nitro, and ester groups
Phase I xenobiotic metabolism involves chemical reactions that prepare foreign compounds for conjugation. While oxidation is the most common reaction, the body also utilizes reduction and hydrolysis pathways. Phase I reductions typically occur on xenobiotics that contain specific reactive groups, such as azo and nitro groups, which are common in various dyes and drugs. Hydrolysis reactions are most likely to affect compounds with ester or amide bonds. These enzymatic modifications are essential for introducing or exposing functional groups that can subsequently be conjugated in Phase II, increasing the polarity of the molecule and facilitating its excretion from the systemic circulation.

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232. (A) Urine
Cultation is a vital Phase II detoxification reaction that occurs in the cytosol of various tissues, particularly the liver. This process is catalyzed by sulfotransferases, which transfer a sulfate group from the donor molecule PAPS to a xenobiotic or its Phase I metabolite. Because the sulfate group is highly polar and fully ionized at physiological pH, its attachment significantly increases the water solubility of the compound. These polar conjugates are then released into the blood and are efficiently eliminated through the kidneys into the urine. This pathway is essential for the rapid clearance of various drugs, hormones, and toxic environmental compounds.

233. (B) 8-9%
The total blood volume is a critical physiological parameter that is closely regulated to maintain cardiovascular stability and tissue perfusion. In typical domestic canine species, the total volume of blood is approximately eight to nine percent of the animal's total body weight. This value represents the combined volume of the plasma and the cellular components, specifically the erythrocytes, leukocytes, and platelets. Knowing the estimated blood volume is essential for clinicians when calculating the severity of hemorrhage, determining fluid therapy requirements, or performing diagnostic procedures that involve the dilution of indicators or the administration of medications in veterinary medicine.

234. (A) ATP
The Rapoport-Luebering shunt is a metabolic adaptation in erythrocytes that allows for the production of 2,3-bisphosphoglycerate. This shunt involves a diversion from the main glycolytic pathway, where 1,3-bisphosphoglycerate is converted to 2,3-BPG instead of proceeding to 3-phosphoglycerate. Because the standard glycolytic step is bypassed, the erythrocyte misses the opportunity to produce a molecule of ATP through substrate-level phosphorylation. Consequently, the synthesis of 2,3-BPG, which is essential for regulating hemoglobin's oxygen affinity, occurs at the direct expense of the cell's

total ATP production. This metabolic trade-off ensures that the red cell can effectively modulate oxygen delivery despite its limited energy budget.

235. (A) Acidic pH and hydrolytic enzymes
During the process of macrophage phagocytosis, an engulfed pathogen is initially trapped within a phagosome. The subsequent fusion of this phagosome with a lysosome creates a lethal internal environment known as a phagolysosome. This compartment is characterized by a very acidic pH, which is achieved through the active pumping of hydrogen ions into the vesicle. This acidity activates a potent mixture of hydrolytic enzymes, such as proteases, nucleases, and lipases, which are released from the lysosome. Together, the low pH and enzymatic activity break down the structural components of the pathogen, ensuring its complete destruction and the safe removal of foreign material.

236. (B) Decreased albumin and elevated globulins
Severe hepatic cirrhosis is a chronic condition characterized by the widespread replacement of healthy liver tissue with non-functional scar tissue. This process leads to a significant reduction in the liver's synthetic capacity, resulting in a marked decrease in serum albumin levels. Simultaneously, the chronic inflammatory state and exposure to antigens that bypass the liver's filtration can lead to an increase in the production of immunoglobulins by the immune system, resulting in elevated globulin concentrations. This distinct pattern of decreased albumin and elevated globulins causes a characteristically low or inverted Albumin:Globulin ratio, which is a classic diagnostic finding in animals with advanced chronic liver disease.

237. (B) Haldane effect
The Haldane effect is a fundamental principle of respiratory physiology that describes how oxygen binding influences the transport of carbon dioxide. Specifically, an increase in the partial pressure of oxygen promotes the oxygenation of hemoglobin, which causes a conformational change that reduces its affinity for carbon dioxide and protons. This shift powerfully displaces carbon dioxide from the hemoglobin molecule, facilitating its release into the alveoli for exhalation. The Haldane effect is essential for ensuring that the blood can efficiently load oxygen while simultaneously unloading metabolic waste, optimizing gas exchange at the respiratory surface and helping to maintain the body's systemic acid-base balance during normal and increased metabolism.

238. (C) pH equals pKa
The buffer capacity of any weak acid/conjugate base pair is a measure of its ability to resist changes in pH upon the addition of an acid or base. According to the principles of acid-base chemistry, this capacity is mathematically and physiologically at its maximum when the concentration of the weak acid is exactly equal to the concentration of its conjugate base. Based on the Henderson-Hasselbalch equation, this state occurs when the pH of the solution is equal to the pKa of the buffer system. Maintaining blood pH relies on several buffer systems, such as the bicarbonate and phosphate systems, operating near their pKa values to provide the greatest possible protection against physiological pH shifts.

239. (B) Facilitate acid excretion and bicarbonate generation
Renal ammonium excretion is a vital mechanism for the regulation of systemic acid-base balance, particularly during states of chronic metabolic acidosis. In response to high acidity, the renal tubular cells upregulate the metabolism of glutamine, which produces ammonium ions and new bicarbonate. The ammonium is secreted into the tubular lumen to be excreted in the urine, effectively eliminating hydrogen ions from the body. Simultaneously, the newly generated bicarbonate is returned to the circulation to replenish the blood's buffering capacity. This dual action of facilitating acid excretion and generating new base is the primary physiological purpose of increased ammonium production in the kidneys during prolonged acidosis.

240. (A) Glucose and Lactate
The Cori cycle is an essential metabolic pathway that ensures continuous energy production during intense physical exertion. It involves a coordinated exchange of metabolites between skeletal muscle and the liver. During anaerobic exercise, muscle cells produce lactate, which is released into the blood and transported to the liver. The liver then utilizes energy to convert this lactate back into glucose through the process of gluconeogenesis. The regenerated glucose is returned to the muscle through the circulation, where it can be used for further ATP production.

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By continuously cycling glucose and lactate, this pathway prevents the excessive accumulation of metabolic waste and helps maintain energy balance between these two tissues.

241. (A) Sulfate and carboxyl groups
Chondroitin sulfate is a major glycosaminoglycan found in the extracellular matrix of cartilage, where it provides structural support and resistance to compression. The molecule consists of repeating disaccharide units that are highly negatively charged. this charge is primarily due to the presence of both sulfate and carboxyl groups attached to the sugar residues. These negative charges attract large amounts of water and cations, creating high osmotic pressure within the matrix. This hydration is essential for the tissue's resilience, allowing cartilage to absorb mechanical shocks and distribute loads across the joint surface. The density of these charged groups is a critical factor in the overall mechanical performance of the cartilage tissue.

242. (C) Alkaline phosphatase
Osteoblasts are the primary cells responsible for the formation and mineralization of new bone tissue. To initiate the deposition of hydroxyapatite crystals, these cells must create an environment with high local concentrations of inorganic phosphate. Osteoblasts achieve this by secreting a specific enzyme called alkaline phosphatase onto the cell surface and into the organic osteoid matrix. This enzyme catalyzes the hydrolysis of organic phosphates, such as pyrophosphate, which is a potent inhibitor of mineralization. By increasing the availability of inorganic phosphate and removing inhibitory molecules, alkaline phosphatase strictly regulates the bone mineralization process. Consequently, its activity in the blood is a standard clinical marker for bone formation and osteoblast function.

243. (A) Local enzymatic reactions vs. axonal transport
Neurotransmitter synthesis involves different pathways depending on whether the transmitter is a small molecule or a peptide. Small-molecule transmitters, like acetylcholine and GABA, are synthesized directly within the presynaptic nerve terminal through local enzymatic reactions. This allow for the rapid replenishment of neurotransmitter stores during periods of high activity. In contrast, peptide neurotransmitters are synthesized in the cell body, or soma, where the necessary genetic and ribosomal machinery is located. Once produced, these peptides must be packaged into vesicles and moved to the terminal via slow or fast axonal transport. This fundamental biochemical distinction determines the rate at which different types of neurotransmitters can be synthesized and released in response to nerve impulses.

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244. (D) Free fatty acids and glycerol
During periods of prolonged starvation or energy deficit, the body must mobilize its energy reserves from adipose tissue. This process, known as lipolysis, involves the sequential breakdown of stored triglycerides by specialized lipase enzymes. The complete hydrolysis of one triglyceride molecule results in the release of three free fatty acids and one molecule of glycerol. These substrates are then released into the blood, leading to a significant increase in their circulating levels. The free fatty acids are transported to the liver and other tissues to be used as fuel through beta-oxidation, while the glycerol serves as a precursor for gluconeogenesis in the liver. This mobilization is essential for maintaining systemic energy balance when dietary sources are unavailable.

245. (B) Beta-1,4
Lactose, the primary carbohydrate found in the milk of mammals, is a disaccharide composed of two simple sugars: glucose and galactose. It is synthesized within the Golgi apparatus of mammary epithelial cells through the action of the enzyme lactose synthase. This biochemical process involves the formation of a specific glycosidic bond between the first carbon of the galactose molecule and the fourth carbon of the glucose molecule. This linkage is definitively identified as a beta-1,4-glycosidic bond. The synthesis of this unique sugar is essential for providing the neonate with an accessible energy source and for maintaining the osmotic balance of the milk during lactation, facilitating the secretion of water and other essential nutrients into the alveolar lumen.

246. (B) Total Iron Binding Capacity (TIBC)
Transferrin is the primary protein responsible for transporting iron through the circulation. Under normal physiological conditions, only about one-third of the available iron-binding sites on the transferrin molecules are occupied.

The total amount of iron that can be bound by all the transferrin present in the blood is clinically measured as the Total Iron Binding Capacity. This parameter provides an indirect assessment of the transferrin concentration. By measuring both the serum iron and the TIBC, clinicians can calculate the percentage of transferrin saturation. These values are essential for diagnosing various iron-related disorders, such as iron deficiency anemia or iron overload states, and for evaluating the animal's overall iron status and transport efficiency in veterinary medicine.

247. (B) Falling serum ionized calcium
The parathyroid glands serve as the primary sensor for systemic calcium levels and play a critical role in maintaining mineral homeostasis. These glands possess specialized calcium-sensing receptors on their cell membranes that continuously monitor the concentration of ionized calcium in the blood. The primary biochemical trigger for the parathyroid glands to sharply increase the secretion of parathyroid hormone is a decrease in circulating ionized calcium. When levels fall below the physiological set point, the glands rapidly release PTH, which then acts on the kidneys, bones, and indirectly on the intestines to mobilize calcium and restore normal blood levels. This immediate and sensitive hormonal response is essential for preventing the adverse effects of hypocalcemia on nerve and muscle function in domestic animals.

248. (A) Uptake, Conjugation, and Biliary Excretion
Hepatic diagnostic dye excretion tests, such as the Bromosulfophthalein test, are designed to evaluate the liver's overall metabolic and secretory capacity. These tests fundamentally assess a sequence of three critical actions performed by the hepatocytes. First, the liver must efficiently take up the dye from the systemic circulation. Second, the dye must be chemically modified, or conjugated, to increase its water solubility. Finally, the resulting conjugate must be actively transported across the canalicular membrane and excreted into the bile. A delay in any of these steps results in a reduced clearance rate from the blood, providing clinicians with a sensitive indicator of liver dysfunction, impaired bile flow, or significant changes in hepatic blood perfusion during veterinary diagnostic investigations.

249. (C) Renal tubules
Urinary casts are microscopic cylindrical structures that form when proteins and other materials precipitate within the renal tubules. The matrix of these casts is primarily composed of Tamm-Horsfall protein, which is secreted by the cells of the ascending limb of the loop of Henle. Because casts are molded within the tubular lumen, their presence in a urinalysis, a condition known as cylindruria, is a definitive diagnostic indicator of disease or injury localized to the renal tubules themselves. The type of cast, whether hyaline, granular, or cellular, can provide further information about the nature and severity of the tubular pathology, such as inflammation, necrosis, or degeneration, helping clinicians identify the specific site of renal damage during a complete diagnostic evaluation.

250. (B) Specific gravity
A complete physical urinalysis is a fundamental component of a diagnostic workup, providing immediate information about an animal's hydration status and renal function. This evaluation encompasses three critical parameters that can be assessed through direct observation and measurement. First, the color of the urine is noted, which can vary due to concentration or the presence of pigments. Second, the clarity or turbidity is evaluated, which may indicate the presence of cells, crystals, or bacteria. Finally, the specific gravity is measured using a refractometer. Specific gravity provides a quantitative assessment of the total solute concentration, reflecting the kidney's ability to concentrate or dilute the urine relative to the plasma. Together, these three physical characteristics provide essential baseline data for interpreting the subsequent chemical and microscopic findings in urinalysis.

251. (A) Glucose concentration
An extreme, acute physiological stress response in wild animals involves the rapid activation of the sympathetic nervous system and the adrenal medulla. This leads to a massive surge of catecholamines, such as epinephrine and norepinephrine, into the systemic circulation. One of the primary metabolic effects of these hormones is to stimulate the breakdown of glycogen in the liver and muscle through glycogenolysis. this result in a rapid and significant spike in blood glucose concentration, providing an immediate energy source for the fight-or-flight response.

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This stress-induced hyperglycemia is a common finding in blood samples collected from captured wild animals and must be differentiated from other metabolic disorders. Monitoring glucose levels helps clinicians assess the animal's immediate metabolic response to the capture process and its overall energy status.

252. (B) Exertional rhabdomyolysis (tying-up)
The pathobiochemical mechanism of capture myopathy in wild animals is most directly analogous to exertional rhabdomyolysis, also known as tying-up, in domestic draft horses. Both conditions are triggered by intense physical exertion and stress that exceeds the muscle's aerobic capacity. this result in severe muscle cell damage and the massive release of intracellular components, such as creatine kinase and myoglobin, into the circulation. The resulting systemic effects, including metabolic acidosis and potential renal failure due to myoglobinuria, are strikingly similar between the two conditions. This comparison helps veterinarians apply established knowledge from equine medicine to the management and treatment of wildlife suffering from capture-related muscle injury, emphasizing the need for rapid stabilization and fluid therapy to mitigate the systemic consequences of widespread muscle destruction during these acute exertional events.

253. (D) Spinal cord
Cheetahs suffering from leukoencephalomyelopathy exhibit a progressive neurological decline that is characterized by distinct pathological changes in the central nervous system. A fundamental hallmark of this disease is the development of bilateral and symmetrical degeneration of the white matter tracts. While lesions can occur throughout the brain, they are most prominently and consistently documented in the spinal cord. This degeneration involves the breakdown of the myelin sheaths that insulate the long axons within the cord, disrupting the transmission of nerve signals between the brain and the rest of the body. This disruption leads to the characteristic clinical signs of ataxia, hind limb weakness, and paresis. The symmetrical nature of the spinal cord lesions is a key diagnostic feature of this condition, highlighting its devastating impact on the cheetah's motor coordination and overall mobility.

254. (C) An endogenous, highly polar molecule
The metabolic purpose of Phase II xenobiotic conjugation is to complete the detoxification process initiated in Phase I. During these reactions, the toxic parent compound or its Phase I metabolite is covalently linked to a specific endogenous molecule provided by the body. These endogenous partners, such as glucuronic acid, sulfate, or glutathione, are all highly polar and water-soluble molecules. By attaching one of these bulky, polar groups to the toxin, the body significantly increases the overall water solubility of the resulting conjugate. This modification not only reduces the compound's reactivity and toxicity but also prevents it from crossing cell membranes and being reabsorbed in the renal tubules. Consequently, the polar conjugate is effectively trapped in the circulation for rapid excretion through the kidneys or the biliary system, ensuring its safe removal.

255. (B) 300 - 500 Daltons
The elimination of xenobiotics and their metabolites occurs through multiple pathways, with biliary excretion serving as a major route for a specific group of compounds. One of the primary factors that determines whether a metabolite will be excreted in the bile rather than the urine is its molecular weight. In most mammalian species, there is a recognized molecular weight threshold for efficient biliary excretion. Compounds that possess a molecular mass exceeding approximately 300 to 500 Daltons are more likely to be actively transported from the hepatocytes into the bile canaliculi. This threshold ensures that large, bulky conjugates, such as those formed during glucuronidation or glutathione conjugation, are effectively cleared from the blood. The biliary route is particularly important for the elimination of various drugs and their metabolites that are too large for efficient renal filtration by the glomerulus.

256. (D) Mean Corpuscular Volume (MCV)
The Mean Corpuscular Volume is a standard hematological index that provides an estimate of the average size of the erythrocytes in a blood sample. It is mathematically calculated by dividing the hematocrit, which is the total volume occupied by the red cells, by the red blood cell count. The result is typically expressed in femtoliters. MCV is a critical parameter for the clinical classification of anemias. For instance, a low MCV indicates microcytic anemia, often

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seen in iron deficiency, while a high MCV suggests macrocytic anemia, which can occur with certain vitamin deficiencies or regenerative responses. By determining the average cell volume, clinicians can gain valuable insights into the underlying cause of a reduction in red cell mass, helping to guide further diagnostic testing and the development of an effective treatment plan for the animal.

257. (A) Hexose monophosphate shunt
Erythrocytes are constantly exposed to oxidative stress, and their protection depends on the tripeptide glutathione. To maintain glutathione in its active, reduced state, the cell utilizes the enzyme glutathione reductase. This enzyme requires the coenzyme NADPH to provide the necessary reducing power. In mammalian erythrocytes, which lack mitochondria, the hexose monophosphate shunt is the only metabolic pathway that can generate NADPH. Therefore, the erythrocyte's ability to neutralize reactive oxygen species and prevent oxidative damage to hemoglobin and the cell membrane is completely dependent on the continuous operation of the HMP shunt. A deficiency in any of the enzymes in this pathway, particularly glucose-6-phosphate dehydrogenase, can lead to increased oxidative hemolysis and significant hematological disease, highlighting the critical role of this pathway in maintaining the longevity and function of red blood cells in domestic animals.

258. (C) Phospholipase A_2
Platelet activation is a complex process that involves the rapid synthesis of lipid mediators to amplify the aggregation response. One of the most important steps in this cascade is the release of arachidonic acid from the phospholipids within the platelet's cell membrane. This release is definitively catalyzed by the specific enzyme phospholipase A_2. Once activated by rising intracellular calcium levels, phospholipase A_2 hydrolyzes the fatty acid chain at the sn-2 position of the phospholipid, liberating free arachidonic acid. The liberated acid then serves as the substrate for the cyclooxygenase pathway, leading to the production of thromboxane A_2. Thromboxane A_2 is a potent mediator that promotes further platelet activation, vasoconstriction, and the formation of a stable blood clot. The activity of phospholipase A_2 is therefore a critical control point in the initiation of the biochemical signaling that drives the process of hemostasis.

259. (A) Alpha-1, Alpha-2, Beta, Gamma
Plasma protein electrophoresis is a diagnostic technique that resolves the complex mixture of proteins in the plasma into several distinct fractions. While albumin forms the largest and most prominent peak, the globulin fraction is normally resolved into four major sub-bands: Alpha-1, Alpha-2, Beta, and Gamma globulins. Each of these fractions contains various proteins with different physiological functions. For example, the alpha globulins include many acute phase reactants and transport proteins, the beta fraction contains fibrinogen and transferrin, and the gamma fraction consists primarily of immunoglobulins. By analyzing the relative proportions of these sub-bands, clinicians can identify specific patterns of protein changes that are characteristic of various conditions, such as chronic inflammation, liver disease, or immune disorders. The standard electrophoretic pattern provides a valuable overview of the animal's systemic protein profile and helps in the diagnostic evaluation of complex medical cases.

260. (D) To the left, increasing oxygen affinity
Carbon monoxide poisoning is extremely dangerous due to its unique biochemical interaction with hemoglobin. When carbon monoxide binds to one or more of the heme sites, it causes a profound conformational change in the entire tetramer. This change shifts the hemoglobin molecule into the R-state, or relaxed state, which has a much higher affinity for oxygen. Consequently, the oxygen dissociation curve for the remaining binding sites is shifted dramatically to the left. While the blood may contain some oxygen, this increased affinity means that the hemoglobin will not release it to the tissues, even in areas with low oxygen tension. The combination of a reduced oxygen-carrying capacity and a failure to release the bound oxygen results in severe systemic hypoxia. This leftward shift is a key reason why even low levels of carboxyhemoglobin can be lethal, as it effectively starves the body's tissues of the oxygen they need for survival.

261. (B) Bicarbonate/carbonic acid system
The bicarbonate/carbonic acid system is the most critical and rapidly responsive extracellular buffer in mammals. It provides the

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primary defense against non-volatile metabolic acids produced during normal and increased metabolism. The system's effectiveness is due to its unique relationship with the respiratory system. When metabolic acids are added to the blood, they react with bicarbonate to form carbonic acid, which then dissociates into carbon dioxide and water. The excess carbon dioxide can be quickly eliminated by the lungs through increased ventilation. This allows the body to rapidly adjust the concentration of the buffering components and maintain systemic pH within a very narrow range. Because it is highly concentrated in the plasma and is directly linked to the control of breathing, the bicarbonate system is the first line of defense in maintaining acid-base homeostasis during acute physiological changes and metabolic challenges in animals.

262. (C) Apical brush border membrane
Carbonic anhydrase is a ubiquitous enzyme that plays a central role in the reabsorption of bicarbonate in the renal tubules. In the proximal convoluted tubule, the enzyme is strategically located in two distinct compartments to ensure maximal efficiency. First, it is present within the cytoplasm of the tubular cells to facilitate the formation of new bicarbonate and hydrogen ions. Second, a significant concentration of the enzyme is found on the apical brush border membrane, directly facing the tubular lumen. This extracellular carbonic anhydrase catalyzes the rapid dehydration of filtered bicarbonate that has reacted with secreted hydrogen ions, forming carbon dioxide and water. The carbon dioxide can then easily diffuse across the cell membrane to be reabsorbed. By positioning the enzyme on the brush border, the tubule ensures that filtered bicarbonate is processed quickly and returned to the circulation, maintaining the blood's essential buffering capacity.

263. (D) Pyruvate and amino groups
The glucose-alanine cycle is a metabolic pathway that functions similarly to the Cori cycle, but it is specifically involved in the transport of nitrogen between skeletal muscle and the liver. During periods of high muscle activity or fasting, proteins are broken down into amino acids. The nitrogen from these amino acids is transferred to pyruvate to form the amino acid alanine. The alanine is then released into the circulation and transported to the liver. In the liver, alanine is converted back into pyruvate and the amino group is removed. The pyruvate is used for gluconeogenesis to produce glucose, which is returned to the muscle, while the amino group is converted into urea for excretion. This cycle allows the body to effectively recycle the carbon skeleton of pyruvate while safely transporting toxic nitrogen waste to the liver for detoxification, ensuring overall nitrogen and energy balance.

264. (A) Scurvy
Vitamin C, or ascorbic acid, is a necessary cofactor for the enzymes responsible for the post-translational modification of collagen. Specifically, it is required for the hydroxylation of proline and lysine residues, which are essential for stabilizing the collagen triple helix. A chronic deficiency in Vitamin C prevents these modifications, leading to the production of weak and structurally defective collagen fibers. This impairment affects all connective tissues in the body, manifesting as a systemic disorder known as scurvy. Clinical signs include fragile blood vessels, poor wound healing, and skeletal abnormalities due to the failure of the organic bone matrix. While scurvy is rare in most domestic animals that can synthesize their own Vitamin C, it is a significant concern in species that must obtain it from their diet, such as primates and guinea pigs, highlighting the importance of this vitamin for maintaining structural integrity and health.

265. (B) Bone-specific alkaline phosphatase (BALP)
Bone turnover is a dynamic process that involves the coordinated activity of osteoblasts and osteoclasts. To monitor this process, clinicians measure specific biochemical markers in the blood that are derived from these bone cells. Bone-specific alkaline phosphatase is a key marker for bone formation. It is an enzyme synthesized and secreted directly by active osteoblasts as they build the organic osteoid matrix and initiate the mineralization process. Unlike other ALP isoforms found in the liver or intestine, BALP is highly specific for skeletal activity. An elevation in BALP levels indicates an increase in bone formation, which can occur during normal growth in young animals or as a response to various metabolic bone diseases and fractures. By assessing BALP activity, veterinarians can gain valuable information about the rate of bone synthesis and the overall functional status of the osteoblast population during the skeletal remodeling process.

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266. (B) SNARE proteins
The release of neurotransmitters at the synapse is a highly organized and rapid process that is essential for nerve signal transmission. Before a nerve impulse arrives, neurotransmitter-filled vesicles are securely tethered to the presynaptic terminal cytoskeleton and docked at the active zone. This docking and the subsequent fusion of the vesicle with the plasma membrane are mediated by a specific complex of proteins known as SNARE proteins. These proteins are located on both the vesicle membrane and the target membrane. When a nerve impulse triggers an influx of calcium ions, the SNARE proteins undergo a conformational change that pulls the two membranes together, allowing them to fuse and release the neurotransmitter into the synaptic cleft. The SNARE complex is therefore the fundamental biochemical machinery that drives calcium-induced exocytosis, ensuring that synaptic signaling occurs with the necessary speed and precision to support the normal function of the animal's nervous system.

267. (A) Leptin
Adipose tissue is not just a site for energy storage; it is also a highly active endocrine organ that secretes several hormones, collectively known as adipokines. One of the most important of these is leptin, which plays a central role in the regulation of systemic energy balance and body weight. Leptin is synthesized and released by adipocytes in proportion to the amount of fat stored in the body. The hormone travels through the blood to the brain, where it binds to specific receptors in the hypothalamus. This binding initiates a signaling cascade that centrally signals satiety, leading to a decrease in appetite and an increase in energy expenditure. By providing the brain with information about the body's energy reserves, leptin helps to maintain long-term energy homeostasis and prevents the development of obesity. Dysregulation of leptin signaling is associated with various metabolic disorders in both wild and domestic animals.

268. (C) UDP-galactose
Lactose is the unique disaccharide found in milk and is synthesized exclusively within the Golgi apparatus of mammary epithelial cells. The biochemical synthesis of lactose is catalyzed by the enzyme complex lactose synthase. This reaction involves the linkage of a galactose molecule to a glucose molecule. The galactose must be provided in an activated, high-energy form, which is definitively identified as uridine diphosphate galactose, or UDP-galactose. The galactosyltransferase component of the enzyme complex transfers the galactose moiety from UDP-galactose to the glucose acceptor. This synthesis is a key feature of mammary gland metabolism during lactation and is essential for providing the neonate with its primary carbohydrate source. The presence of lactose also helps maintain the osmotic pressure of the milk, facilitating the secretion of water and other essential nutrients into the alveolar lumen for consumption by the developing offspring.

269. (D) Desquamation of mucosal/epidermal cells
Iron is an essential element that is rigidly conserved within the mammalian body to prevent both deficiency and toxicity. Unlike many other minerals, the body lacks a major physiological pathway for the active excretion of excess iron through the kidneys or the liver. Instead, the primary route for the obligate, daily loss of iron is through the natural process of desquamation. As the cells of the skin and the mucous membranes of the gastrointestinal tract and the respiratory system are shed, the small amount of iron they contain is lost to the environment. This constant but limited loss is the only way the body naturally eliminates iron, meaning that systemic iron levels are primarily regulated at the site of absorption in the intestine. This conservation mechanism is highly efficient but also makes the body vulnerable to iron overload if dietary intake exceeds the limited capacity for loss through cellular shedding.

270. (C) Osteoclast-mediated bone resorption
Parathyroid hormone is the master regulator of systemic calcium levels and is released by the parathyroid glands in response to hypocalcemia. One of its most rapid and effective actions to increase blood calcium is the activation of bone resorption. PTH binds to receptors on osteoblasts, which then release signaling molecules that stimulate the activity and differentiation of osteoclasts. These specialized cells then initiate the breakdown of the mineralized bone matrix, a process known as osteoclast-mediated bone resorption. As the hydroxyapatite crystals are dissolved, large amounts of calcium and phosphate are released into the systemic circulation. This hormonal action effectively mobilizes the body's mineral reserves stored in

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the skeleton to restore normal blood calcium concentrations. The activation of osteoclasts is a critical component of the body's homeostatic response, ensuring that calcium is available for essential functions like nerve signal transmission and muscle contraction in domestic animals.

271. (B) Bilirubin
Cholestasis is a clinical condition characterized by the impairment or complete obstruction of bile flow from the liver to the intestine. In the diagnosis of this disorder, clinicians rely on specific biochemical markers in the blood. Serum Alkaline Phosphatase is one of the most sensitive indicators of cholestasis. When bile flow is obstructed, the cells lining the bile ducts increase their synthesis of ALP, and the enzyme is subsequently released into the blood. In most animals, this marked elevation of ALP typically precedes the rise of bilirubin, which is the pigment that causes jaundice. Bilirubin levels only increase when the biliary obstruction is severe enough to overwhelm the liver's ability to excrete it. Therefore, monitoring ALP is a valuable early diagnostic tool for detecting biliary tract disorders and differentiating them from other causes of liver disease, as it often provides the first biochemical sign of an underlying problem with the bile drainage system.

272. (D) Functioning nephrons
The glomerular filtration rate is the most important clinical measurement of overall renal function. It represents the total volume of fluid that is filtered by all the glomeruli in both kidneys per unit of time. Because the process of filtration is the primary function of the glomerulus and the associated tubular system, the GFR accurately reflects the total functional mass of functioning nephrons. When the number of healthy nephrons decreases due to disease or injury, the overall filtration rate falls in a predictable manner. Therefore, measuring GFR, either through the clearance of markers like creatinine or inulin, provides clinicians with a direct and reliable assessment of how much working kidney tissue is remaining. A significant decline in GFR is the hallmark of chronic kidney disease and is used to determine the severity of renal impairment and the overall prognosis for the animal, guiding the development of appropriate management and treatment strategies.

273. (A) Diabetic ketoacidosis
Urinalysis is a critical diagnostic tool that provides information about the animal's metabolic status. The concurrent presence of significant amounts of ketones and glucose in the urine is a hallmark indicator of diabetic ketoacidosis. This condition occurs in animals with uncontrolled diabetes mellitus, where a lack of insulin prevents cells from utilizing glucose for energy. To compensate, the body shifts to massive fat mobilization and hepatic ketogenesis, leading to the accumulation of ketone bodies in the blood and their subsequent excretion in the urine. Simultaneously, the extreme hyperglycemia exceeds the renal threshold, resulting in glycosuria. The combination of ketonuria and glycosuria definitively distinguishes diabetic ketoacidosis from other conditions like simple starvation, where only ketones would be present, or renal glucosuria, where only glucose would be found. DKA is a life-threatening emergency that requires immediate medical intervention to stabilize blood sugar, correct acidosis, and restore fluid and electrolyte balance.

274. (C) In a tranquilized, un-stressed state
The establishment of reliable baseline hematology and biochemistry reference intervals for wildlife is essential for monitoring animal health and population trends. However, these values can be significantly distorted by the stress of the capture process. To obtain accurate reference data that truly reflects the normal physiological state of the animal, it is critical to analyze blood samples collected from individuals that are in a tranquilized and un-stressed state. Ideally, this involves minimal physical pursuit and the use of specialized sedation protocols that reduce the animal's fear and the resulting surge of catecholamines and cortisol. Samples collected from animals that have been under maximal physical restraint or have undergone prolonged pursuit will often show artifactual changes in parameters such as glucose, hematocrit, and electrolytes due to the fight-or-flight response. By minimizing capture-related stress, researchers can ensure that their data is scientifically valid and provide a true baseline for clinical comparison in wildlife medicine.

275. (A) Kidneys
Capture myopathy is a severe and often fatal condition in wild animals that is characterized by acute rhabdomyolysis following the stress of

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pursuit and capture. This massive destruction of skeletal muscle cells leads to the systemic release of intracellular contents, including enzymes like creatine kinase and the oxygen-binding protein myoglobin. Once in the circulation, high concentrations of myoglobin are filtered by the glomeruli and enter the renal tubules. In an acidic environment, which is common during the metabolic acidosis associated with capture myopathy, myoglobin is highly nephrotoxic. It causes direct injury to the tubular epithelial cells and can lead to the formation of casts that obstruct the tubules. this result in terminal failure of the kidneys, which is a major cause of death in affected animals. Preventing this acute renal failure through aggressive fluid therapy and the management of acidosis is a critical component of the treatment protocol for wild animals suffering from severe muscle injury.

276. (D) Peripheral insulin resistance
Diabetes mellitus in aging, captive non-human primates is a progressive metabolic disorder that closely mimics Type 2 diabetes in humans. The development of this condition is intrinsically linked with the chronic presence of peripheral insulin resistance. This resistance is often a consequence of a sedentary lifestyle and obesity in a captive environment. Initially, the pancreatic beta cells increase insulin production to compensate for the tissues' lack of response, resulting in hyperinsulinemia. However, as the disease progresses, the sustained demand for high levels of insulin eventually leads to beta-cell exhaustion and a decline in synthetic capacity. The combination of insulin resistance and the eventual failure of the pancreas culminates in chronic hyperglycemia and the various clinical complications of diabetes. Regular monitoring of weight and glucose metabolism is essential for managing captive primate populations and for preventing the onset of this metabolic disease by mitigating the factors that contribute to insulin resistance.

277. (B) An iron-protoporphyrin IX group
The Cytochrome P450 enzymes are a large and essential family of proteins that serve as the primary catalysts for Phase I xenobiotic metabolism. These enzymes are biochemically characterized as hemoproteins because their active site rigidly incorporates a specific chemical group known as an iron-protoporphyrin IX group, also called heme. The iron atom within this heme group is the site where molecular oxygen and the substrate bind during the catalytic cycle. The iron undergoes changes in its oxidation state as it facilitates the transfer of electrons and the subsequent hydroxylation of the xenobiotic. The presence of this heme group is what gives these enzymes their characteristic light-absorption property at 450 nanometers when bound to carbon monoxide, giving them their name. The P450 system's reliance on the heme iron is fundamental to its ability to catalyze diverse oxidation reactions, protecting the body from a wide range of toxic environmental compounds and drugs.

278. (C) Cats
Glucuronidation is one of the most important Phase II detoxification pathways in mammals, involving the attachment of a glucuronic acid moiety to various toxins to facilitate their excretion. This process is catalyzed by the enzyme UDP-glucuronosyltransferase. However, the efficiency of this pathway varies significantly between species. Domestic cats are notoriously deficient in several UGT isoenzymes, which limits their ability to metabolize and detoxify certain compounds, particularly phenols and many common drugs like acetaminophen. This genetic deficiency makes cats highly susceptible to poisoning from substances that are easily cleared by other domestic species like dogs or horses. Because the glucuronidation pathway is impaired, these toxins can accumulate to lethal levels in the cat's blood and tissues, causing severe oxidative damage or organ failure. This species-specific biochemical characteristic is a critical consideration for veterinarians when prescribing medications or identifying potential household hazards for feline patients, as their unique metabolic profile requires specialized care.

279. (D) Sodium and water
The total volume of blood in the systemic circulation is a critical physiological parameter that must be tightly regulated to maintain blood pressure and ensure adequate tissue perfusion. The primary organ responsible for this long-term regulation is the kidney. The kidneys control blood volume by modulating the reabsorption of sodium and water from the renal tubules back into the circulation. This process is governed by a complex interplay of hormones, including aldosterone, which increases sodium reabsorption,

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and antidiuretic hormone, which increases water reabsorption. When blood volume or pressure falls, the kidneys conserve these substances to increase the systemic fluid volume. Conversely, if volume is excessive, the kidneys increase the excretion of sodium and water in the urine. By adjusting the balance of these two components, the kidneys maintain the overall fluid status of the animal, ensuring that the cardiovascular system can function effectively under various physiological conditions and metabolic demands in domestic animals.

280. (A) ATP for synthetic processes
The Rapoport-Luebering shunt is a specialized metabolic pathway that operates efficiently within mammalian erythrocytes to synthesize 2,3-bisphosphoglycerate. This shunt involves a diversion from the main glycolytic pathway, which results in the sacrifice of ATP production. This metabolic trade-off is possible exclusively because mature mammalian erythrocytes lack most organelles and do not perform DNA replication, protein synthesis, or other energy-intensive synthetic processes. Their primary function is the transport of gases, which requires only a small amount of ATP to maintain membrane ion pumps and overall cell shape. Because their demand for energy is so limited, the red cell can afford to bypass the ATP-generating steps of glycolysis to produce 2,3-BPG, which is a critical allosteric regulator of hemoglobin's oxygen affinity. This adaptation ensures that the erythrocyte can effectively fulfill its physiological role in oxygen delivery while operating on a minimal energy budget that is sufficient for its specialized and simplified cellular structure.

281. (B) Molecular oxygen
The respiratory burst is a critical and rapid metabolic response in activated macrophages that is designed to destroy engulfed pathogens. This process is initiated when the macrophage encounters a microorganism, triggering the activation of the enzyme NADPH oxidase. The enzyme catalyzes the transfer of electrons from NADPH to molecular oxygen, resulting in a massive and sudden increase in the cellular consumption of oxygen. This rapid uptake is often referred to as the "burst" because it occurs so quickly following phagocytosis. The primary purpose of this oxygen consumption is to generate superoxide anions and other highly reactive oxygen species within the phagolysosome. These reactive molecules are extremely toxic to pathogens, causing oxidative damage to their proteins, lipids, and DNA. The respiratory burst is therefore a key component of the innate immune system's ability to neutralize infections and clear foreign material, highlighting the importance of molecular oxygen for effective immune defense in the animal's body.

282. (A) Alpha-1 globulin
Plasma protein electrophoresis resolves the complex mixture of proteins in the blood into several distinct fractions, each containing various functional molecules. The alpha-1 globulin fraction is an important part of this profile, as it contains several critical transport and protective proteins. One of the most significant proteins in this fraction is alpha-1 antitrypsin. This molecule functions as a potent protease inhibitor, protecting the body's tissues from the damaging effects of inflammatory enzymes like elastase, which are released by neutrophils during an immune response. Without the protective action of alpha-1 antitrypsin, these enzymes could cause widespread destruction of connective tissue, leading to disorders like emphysema or liver injury. In addition to antitrypsin, the alpha-1 fraction also includes proteins like serum amyloid A, which is an acute phase reactant. Monitoring the alpha-1 globulin peak provides clinicians with valuable information about the animal's inflammatory status and its ability to modulate the activity of potentially harmful enzymes during tissue injury.

283. (A) First oxygen molecule binding
Hemoglobin is a complex tetrameric protein that undergoes significant structural changes to fulfill its role in gas transport. It exists in two primary conformational states: the T-state, which has a low affinity for oxygen, and the R-state, which has a high affinity. The transition from the tense T-state to the relaxed R-state is a key feature of cooperative binding and is immediately triggered by the binding of the first oxygen molecule to one of the heme sites. This binding event causes a slight shift in the position of the iron atom, which is transmitted through the protein chains, breaking several stabilizing salt bridges. These changes make it much easier for subsequent oxygen molecules to bind to the remaining sites, leading to the rapid saturation of the hemoglobin molecule in the oxygen-rich environment of the lungs. This allosteric transition is essential for

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ensuring that hemoglobin can efficiently load oxygen while also maintaining the ability to release it in the tissues.

284. (C) 20:1
The bicarbonate/carbonic acid system is the primary extracellular buffer responsible for maintaining blood pH within the narrow range required for life. According to the Henderson-Hasselbalch equation, the pH of a buffer solution depends on the ratio of the conjugate base to the weak acid. At a normal physiological blood pH of 7.4, the ratio of bicarbonate to dissolved carbon dioxide is approximately twenty to one. This large excess of bicarbonate relative to CO_2 provides a significant "alkaline reserve," allowing the body to effectively neutralize the large amounts of metabolic acids produced during normal daily activities. Because carbon dioxide can be rapidly adjusted by the respiratory system and bicarbonate can be regulated by the kidneys, the body can maintain this 20:1 ratio with great precision. Any significant shift in this ratio results in a change in blood pH, leading to the development of respiratory or metabolic acidosis or alkalosis, which are critical acid-base disorders in veterinary medicine.

285. (D) Gluconeogenesis and glutamine metabolism
The kidneys play a critical role in the long-term regulation of systemic acid-base balance, particularly during states of chronic metabolic acidosis. To compensate for the accumulation of metabolic acids, the kidneys significantly upregulate several biochemical pathways within the tubular cells. The most important of these changes is an increase in the enzymes involved in glutamine metabolism and gluconeogenesis. The metabolism of the amino acid glutamine produces ammonium ions and new bicarbonate. The ammonium is secreted into the urine to eliminate hydrogen ions, while the generated bicarbonate is returned to the circulation to restore the blood's buffering capacity. Gluconeogenesis also contributes to this process by utilizing the carbon skeleton of glutamine to produce glucose, which can be used for energy. By coordinating these two pathways, the kidneys are able to eliminate significant amounts of metabolic acid while simultaneously replenishing the body's essential alkaline reserves, ensuring the maintenance of physiological pH during prolonged periods of metabolic challenge.

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286. (C) Phosphofructokinase
Muscle fatigue during intense anaerobic exercise is a complex physiological phenomenon that is directly influenced by changes in the muscle's biochemical environment. As the muscle relies on anaerobic glycolysis to meet high energy demands, it produces large amounts of lactic acid, which dissociates into lactate and hydrogen ions. This accumulation of protons leads to a precipitous decline in the intracellular pH of the sarcoplasm. This acidic environment has a powerful inhibitory effect on several key enzymes, most notably phosphofructokinase. PFK is the rate-limiting enzyme of the glycolytic pathway, and its activity is highly sensitive to pH. When pH falls, the enzyme is inhibited, which significantly slows down the rate of glycolysis and the overall production of ATP. By restricting energy supply during periods of extreme acidity, this feedback mechanism acts as a protective response to prevent permanent cellular damage from overexertion, but it also directly contributes to the decline in muscle performance and the onset of fatigue.

287. (B) Cell surface integrin receptors
Fibronectin is a multifunctional adhesive glycoprotein found in the extracellular matrix and the blood that plays a critical role in cell attachment and tissue organization. Its primary function is to serve as a molecular bridge between the structural components of the matrix and the cells themselves. Fibronectin achieves this by possessing several distinct and specific binding domains. One of these domains allows it to bind to collagen fibers, while another domain is recognized by integrin receptors on the cell surface. By linking the collagen network to the cell's cytoskeleton, fibronectin facilitates cell migration, wound healing, and the overall stability of the connective tissue. This interaction is essential for normal tissue development and repair, as it ensures that cells are correctly positioned and securely anchored within their environment. The ability of fibronectin to coordinate these various structural and cellular components makes it a vital protein for maintaining the mechanical and functional integrity of tissues in domestic animals.

288. (D) Osteoclast activity
Tartrate-Resistant Acid Phosphatase is a specialized enzyme that is highly expressed in the lysosomes of osteoclasts. During the process of

bone resorption, osteoclasts release this enzyme into the sealed resorptive compartment between the cell and the bone surface. TRAP functions in the degradation of the organic components of the bone matrix and the breakdown of mineral crystals. Because the enzyme is uniquely associated with these bone-resorbing cells and its activity increases significantly during their activation, it is universally recognized as a specific biochemical marker for osteoclast activity. Measuring TRAP levels in the blood provides clinicians with a reliable indicator of the rate of bone mineral breakdown and overall resorption. This marker is particularly valuable for diagnosing metabolic bone diseases characterized by increased skeletal turnover, such as hyperparathyroidism or certain malignant conditions, and for monitoring the animal's response to treatments aimed at inhibiting bone resorption and maintaining skeletal health in veterinary practice.

289. (A) GLUT-1
Brain energy metabolism is highly active and requires a constant and reliable supply of glucose to maintain normal neurological function. Because glucose is a polar molecule, it cannot easily cross the lipid-rich blood-brain barrier by simple diffusion. Instead, its transport into the brain is strictly dependent on specialized carrier proteins. The primary glucose transporter located on the endothelial cells of the brain capillaries is GLUT-1. This transporter facilitates the movement of glucose from the blood into the brain tissue according to the concentration gradient. GLUT-1 is characterized by its high affinity for glucose, ensuring that the brain receives an adequate supply even when blood sugar levels are relatively low. This transporter is essential for the continuous delivery of fuel to the neurons, supporting the immense energy demands of signal transmission and metabolic maintenance. Dysregulation of GLUT-1 transport can lead to significant neurological impairment, highlighting the critical role of this protein in the biochemistry of the central nervous system.

290. (C) Elevated intracellular cAMP
Lipolysis in adipose tissue is a highly regulated process that mobilizes stored energy in response to hormonal signals during periods of fasting or stress. The primary enzyme responsible for the breakdown of triglycerides is hormone-sensitive lipase. The activation of HSL is controlled by a signaling cascade that is initiated when hormones like epinephrine bind to beta-adrenergic receptors on the adipocyte membrane. This binding activates adenylate cyclase, which leads to an increase in the intracellular concentration of cyclic AMP. High levels of cAMP then activate Protein Kinase A, which directly phosphorylates HSL. This phosphorylation is the definitive biochemical trigger that activates the lipase, allowing it to hydrolyze stored fats into free fatty acids and glycerol. This signaling pathway ensures that the mobilization of energy reserves is tightly coordinated with the animal's metabolic needs and stress levels, acting immediately downstream of the rise in cAMP to provide a rapid and effective response to systemic energy demands.

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291. (A) Immunoglobulins
The composition of milk is highly specialized to meet the nutritional and immunological needs of the neonate. Most milk proteins, including the various caseins and whey proteins like alpha-lactalbumin, are synthesized de novo within the mammary alveolar epithelial cells using amino acids from the blood. However, there are notable exceptions to this rule. Certain proteins, most significantly the immunoglobulins, are not synthesized in the mammary gland. Instead, they are derived directly from the maternal blood and are actively transported across the alveolar cells into the milk. This process is particularly intense during the formation of colostrum, which is the first milk produced after birth. The transfer of these pre-formed antibodies from the mother is essential for providing the neonate with passive immunity, protecting them from infections during the early stages of life before their own immune system is fully developed. This transfer highlights the importance of the mammary gland as a site for both synthesis and specialized transport of maternal blood proteins.

292. (D) Cretinism
Iodine is an essential trace element required for the synthesis of the thyroid hormones thyroxine and triiodothyronine. These hormones are critical for the normal regulation of metabolism, growth, and development, particularly in the brain. A severe iodine deficiency during fetal development or early mammalian infancy results in a catastrophic pathobiochemical syndrome known as cretinism. Affected animals exhibit profound physical and mental retardation,

II. In normal-phase adsorption chromatography, the stationary phase is non-polar and the mobile phase is polar.
III. Cation-exchange chromatography utilizes a negatively charged stationary phase to bind positively charged molecules.

Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2014

8. In Gas Chromatography (GC), what determines the retention time of a volatile compound?
(A) Vapor pressure and affinity for the stationary phase.
(B) The specific flow rate of the inert carrier gas used.
(C) The chemical molecular weight of the stationary phase.
(D) The peak UV absorbance of the volatile analyte.

2005

9. Select the correct sequence of events in gel filtration (size-exclusion) chromatography.
(A) Smallest molecules elute first, followed by intermediate, then largest molecules.
(B) Largest molecules elute first, followed by intermediate, then smallest molecules.
(C) Molecules elute strictly based on their net charge, regardless of size.
(D) Molecules elute based on specific ligand-receptor interactions.

2015

10. Which correctly pairs an electrophoretic technique with its primary application?
(A) Native PAGE - Separation of proteins based solely on molecular weight
(B) Agarose gel electrophoresis - Resolution of large DNA fragments
(C) SDS-PAGE - Separation of proteins while maintaining their folded conformation
(D) Capillary electrophoresis - Purification of whole cells

2017

11. Which pair INCORRECTLY matches an isoelectric focusing (IEF) concept with its definition?
(A) Cathode - The positively charged electrode where low pH is maintained
(B) Isoelectric point (pI) - The pH at which a molecule carries no net electrical charge
(C) Ampholytes - Carrier molecules used to establish a stable pH gradient
(D) 2D gel electrophoresis - Combines IEF in the first dimension and SDS-PAGE in the second

2009

12. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.

Assertion (A): Liquid scintillation counting is highly efficient for detecting low-energy beta emitters like Tritium (^3H).

Reason (R): The technique dissolves the radioactive sample directly into a fluor-containing solvent, minimizing self-absorption.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

13. During the standard extraction of genomic DNA using the phenol-chloroform method, what is the primary function of phenol?
(A) To precipitate genomic DNA from the solution.
(B) To act as a chelating agent for magnesium ions.
(C) To degrade all contaminating cellular RNA.
(D) To denature and partition proteins away.

2019

14. What is the most appropriate interpretation of an $\frac{A_{260}}{A_{280}}$ ratio of 1.4 in a purified RNA sample?
(A) The sample is highly pure RNA.
(B) The sample is highly pure DNA.
(C) The sample contains significant protein.
(D) The sample contains significant phenol.

2008

15. Given below are statements regarding the Polymerase Chain Reaction (PCR):
I. The denaturation phase typically occurs at 94-98°C to separate double-stranded DNA.
II. Taq polymerase is utilized because of its high proofreading activity compared to Pfu polymerase.
III. The annealing temperature is determined by the melting temperature (T_m) of the primers.

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Bence-Jones proteins is much lower. Therefore, a positive protein result on a dipstick is primarily an indicator of albuminuria. This sensitivity makes the dipstick a valuable screening tool for identifying animals with potential renal disease, although positive results must be confirmed with more quantitative and specific methods, such as the urine protein-to-creatinine ratio, for a complete diagnostic evaluation.

297. (B) Potassium
Physiological fluid and electrolyte shifts are a common occurrence in wild herbivores during the stress of immobilization and capture. These animals are particularly susceptible to rapid changes in their systemic electrolyte balance due to the intense exertion and the hormonal surge associated with the capture process. One of the most frequently documented changes is a rapid, stress-induced decrease in the serum concentration of potassium ions, a condition known as hypokalemia. This shift is primarily driven by the release of catecholamines, such as epinephrine, which stimulate the uptake of potassium into the cells from the extracellular fluid. The resulting decrease in circulating potassium can have significant effects on cardiac and muscle function, potentially leading to arrhythmias or weakness during the recovery from sedation. Monitoring electrolyte levels, particularly potassium, is therefore a critical part of the clinical management of immobilized wildlife, ensuring that any significant imbalances are identified and addressed to minimize the risks associated with the capture and handling process.

298. (A) Fatal cardiac arrhythmias
Capture myopathy is a severe condition that can lead to rapid death in wild animals, and the specific pathobiochemical mechanism triggering these terminal events is often linked to electrolyte imbalances. During the widespread destruction of muscle cells, large amounts of intracellular components are released into the systemic circulation. One of the most dangerous consequences of this release is a profound increase in blood potassium levels, known as hyperkalemia. High potassium concentrations significantly alter the resting membrane potential of cardiac myocytes, interfering with the heart's normal electrical conduction. This disruption can lead to the development of fatal cardiac arrhythmias, where the heart is unable to maintain a stable and effective rhythm. The sudden onset of these arrhythmias is a frequent cause of acute death in animals suffering from advanced capture myopathy, often occurring during or shortly after the capture event. Managing potassium levels and supporting cardiovascular function are therefore vital considerations in the emergency treatment of wildlife affected by this severe muscle-wasting disorder.

NODIA

299. (A) Type 2 Diabetes
Managing captive non-human primates requires careful attention to their metabolic health, as they are highly susceptible to developing Type 2 diabetes mellitus. The pathogenesis of this condition in primates is intrinsically linked with the chronic development of obesity and a sedentary lifestyle in a captive environment. These factors lead to the onset of peripheral insulin resistance, where the animal's tissues no longer respond appropriately to the insulin produced by the pancreas. Initially, the body compensates for this resistance by increasing insulin secretion, but over time, the beta cells become exhausted, resulting in chronic hyperglycemia. Regular biochemical monitoring of blood glucose and glycated hemoglobin is essential for identifying the early signs of metabolic dysfunction. By implementing strategies to control weight and promote physical activity, clinicians can directly mitigate the onset of Type 2 diabetes, preventing the various long-term complications associated with the disease and ensuring the overall wellbeing and longevity of captive primate populations in zoological and research settings.

300. (C) The hydroxylated product and a molecule of water
The Cytochrome P450 monooxygenase cycle is a complex sequence of biochemical events that modifies xenobiotics to increase their water solubility. The cycle fundamentally terminates following the rapid transfer of a second electron to the iron-oxygen-substrate complex. This electron transfer triggers the immediate and final cleavage of the oxygen-oxygen bond. As a result, one atom of oxygen is incorporated into the substrate molecule to form the hydroxylated product, while the other atom of oxygen is reduced to form a molecule of water. The release of these two products allows the enzyme to return to its original, oxidized ferric state, ready to initiate a new catalytic cycle. This final step is critical for completing the modification

sites under sub-optimal conditions
(C) Exonuclease activity that degrades the DNA ends
(D) Spontaneous denaturation at 37°C

2002

42. Order the steps for performing a Southern blot.
I. Transfer of DNA to a nitrocellulose or nylon membrane
II. Restriction enzyme digestion of genomic DNA
III. Hybridization with a labeled specific probe
IV. Agarose gel electrophoresis
(A) II, IV, I, III
(B) IV, II, I, III
(C) II, I, IV, III
(D) I, II, IV, III

2007

43. What is the fundamental difference between Northern blotting and Southern blotting?
(A) Northern blotting analyzes DNA, while Southern blotting analyzes RNA.
(B) Northern blotting analyzes RNA, while Southern blotting analyzes DNA.
(C) Northern blotting uses antibodies, while Southern blotting uses nucleic acid probes.
(D) Northern blotting requires polyacrylamide gels, while Southern blotting uses agarose.

2016

44. Which vector is specifically designed to accommodate very large DNA inserts up to 300 kb, making it suitable for constructing genomic libraries?
(A) pBR322
(B) pUC19
(C) Bacterial Artificial Chromosome (BAC)
(D) M13 bacteriophage

2024

45. In a competitive Radioimmunoassay (RIA), the amount of radioactivity measured in the bound fraction is:
(A) Directly proportional to the concentration of unlabeled antigen in the patient sample.
(B) Inversely proportional to the concentration of unlabeled antigen in the patient sample.
(C) Unaffected by the concentration of unlabeled antigen.
(D) Exponentially related to the antibody concentration.

2015

46. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): MALDI-TOF mass spectrometry is widely used to identify bacteria based on their unique protein profiles.
Reason (R): MALDI involves a soft ionization technique that prevents the extensive fragmentation of large biomolecules like proteins.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

47. Which nanomaterial is most commonly utilized in lateral flow assays (like pregnancy tests) to provide the visible read-out line?
(A) Carbon nanotubes
(B) Quantum dots
(C) Gold nanoparticles
(D) Magnetic iron oxide nanoparticles

2008

48. An elevation in which enzyme is the most specific indicator of skeletal muscle damage in horses?
(A) Alkaline phosphatase (ALP)
(B) Creatine kinase (CK)
(C) Gamma-glutamyl transferase (GGT)
(D) Amylase

2019

49. In veterinary medicine, an elevated concentration of ketone bodies (β-hydroxybutyrate, acetoacetate) is most characteristically associated with which condition?
(A) Chronic renal failure
(B) Diabetic ketoacidosis
(C) Primary hyperparathyroidism
(D) Hypothyroidism

2005

50. Which immunoassay marker is specifically measured to confirm the occurrence of ovulation in domestic animals such as cattle and dogs?
(A) Progesterone
(B) Estrogen
(C) Testosterone
(D) Thyroxine

2001

51. The phenomenon where a fluorescent molecule absorbs light at one wavelength and emits light at a longer wavelength is characterized by which term?

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CHAPTER 09
Determination of Biochemical Constituents

2009

1. What is the fundamental principle described by the Beer-Lambert law in UV-Visible spectrophotometry?
(A) Absorbance is directly proportional to concentration and path length.
(B) Transmittance increases linearly with the concentration of the solute.
(C) Absorbance is inversely proportional to the path length of the cuvette.
(D) The intensity of emitted fluorescence is equal to the concentration.

2011

2. Which light source is most commonly utilized in Atomic Absorption Spectroscopy (AAS) to provide element-specific emission lines?
(A) Tungsten-halogen lamp
(B) Deuterium arc lamp
(C) Hollow cathode lamp
(D) Xenon arc lamp

2005

3. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): In density gradient centrifugation, particles separate solely based on their size and shape.
Reason (R): The density of the surrounding medium increases gradually from top to bottom, affecting particle sedimentation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

4. In sub-cellular fractionation, which physical cell disruption method relies on forcing a cell suspension through a narrow valve under high pressure?
(A) Ultrasonic probe sonication
(B) Manual Dounce homogenization
(C) Targeted enzymatic lysis
(D) French press homogenization

2005

5. Match the items in List I with those in List II.
List I: (Technique)
P. Salting out
Q. Dialysis
R. Ultrafiltration
S. Salting in
List II: (Mechanism)
1. Separation based on molecular weight cutoff using semi-permeable membranes under pressure
2. Decreased protein solubility at high salt concentrations due to competition for water
3. Increased protein solubility at low salt concentrations via electrostatic interactions
4. Removal of small molecules through a semi-permeable membrane by passive diffusion
(A) P-II, Q-IV, R-I, S-III
(B) P-III, Q-I, R-IV, S-II
(C) P-II, Q-I, R-IV, S-III
(D) P-I, Q-IV, R-II, S-III

2007

6. Which of the following statements about protein quantification assays is INCORRECT?
(A) The Lowry assay relies on the reduction of the Folin-Ciocalteu reagent by tyrosine and tryptophan residues.
(B) The Bradford assay measures the shift in absorbance of Coomassie Brilliant Blue G-250 from 465 nm to 595 nm.
(C) The BCA assay is highly susceptible to interference from common detergents like SDS.
(D) UV spectrophotometry at 280 nm quantifies proteins primarily based on their aromatic amino acid content.

NODIA

2018

7. Given below are statements regarding chromatography:
I. Partition chromatography separates solutes based on their relative solubilities in two immiscible liquid phases.

of the toxin and for regenerating the P450 enzyme, ensuring a continuous and efficient detoxification process. The production of the hydroxylated metabolite is the primary goal of Phase I metabolism, providing a polar site for subsequent conjugation and eventual excretion from the systemic circulation in mammals.

****

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IV. Quantitative PCR (qPCR) monitors the amplification of targeted DNA in real-time.

Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

2010

16. Restriction Fragment Length Polymorphism (RFLP) analysis fundamentally relies on which biological phenomenon?
(A) Ability of RNA polymerase to synthesize cDNA
(B) Separation of proteins based on isoelectric points
(C) Random mutation of various restriction enzymes
(D) Variations in length of specific DNA fragments

2011

17. Match the items in List I with those in List II.

List I: (Element)
P. VNTRs
Q. Microsatellites
R. Minisatellites
S. RFLP

List II: (Characteristic)
1. Short tandem repeats (STRs) typically 2-6 base pairs long
2. Repeats typically 10-60 base pairs long, highly polymorphic
3. Relies on point mutations altering restriction enzyme recognition sites
4. General term encompassing various tandem repeat loci used in profiling

(A) P-IV, Q-I, R-II, S-III
(B) P-I, Q-IV, R-III, S-II
(C) P-IV, Q-II, R-I, S-III
(D) P-II, Q-I, R-IV, S-III

2007

18. A researcher observes an unexpected band on a Southern blot. What is the most likely cause?
(A) The use of an RNA probe instead of a DNA probe
(B) Incomplete transfer of proteins from the gel to the membrane
(C) Non-specific hybridization due to low stringency conditions
(D) Over-amplification during the PCR step

2002

19. Based on cloning capacity, classify the vectors from lowest to highest carrying capacity.
(A) Plasmid, Bacteriophage lambda, BAC, YAC
(B) Plasmid, BAC, Bacteriophage lambda, YAC
(C) Bacteriophage lambda, Plasmid, YAC, BAC
(D) YAC, BAC, Bacteriophage lambda, Plasmid

2017

20. Given below are statements regarding ELISA formats:
I. In direct ELISA, the primary antibody is directly conjugated to an enzyme.
II. Indirect ELISA offers higher sensitivity than direct ELISA due to signal amplification by secondary antibodies.
III. Sandwich ELISA requires the antigen to have at least two distinct epitopes.
IV. In competitive ELISA, higher target antigen concentration results in a stronger final colorimetric signal.
V. ELISA relies on the specific interaction between an antigen and an antibody.

Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) IV only
(C) II and III
(D) V only

2014

21. When comparing DNA microarrays to LC-MS, which statement correctly highlights their distinct analytical applications?
(A) Microarrays find protein weights, while LC-MS profiles genes.
(B) Microarrays analyze transcription, while LC-MS profiles proteins.
(C) Microarrays measure DNA, while LC-MS measures metabolites.
(D) Microarrays sequence genomes, while LC-MS sequences RNA.

NODIA

2016

22. Arrange the following steps for utilizing nanoparticles in targeted drug delivery in the correct sequence.
I. Surface functionalization of nanoparticles with targeting ligands
II. Encapsulation or attachment of the therapeutic agent
III. Intravenous administration of the nanoparticle construct
IV. Binding of nanoparticles to specific cellular receptors

including stunted growth, skeletal abnormalities, and impaired neurological function. The lack of sufficient thyroid hormones during these critical periods leads to irreversible damage to the developing central nervous system and other vital organs. While goiter is a common sign of iodine deficiency in older animals, cretinism represents the most severe manifestation of nutritional deficiency during early life. This condition highlights the absolute necessity of adequate iodine intake for pregnant and lactating mothers to ensure the healthy development of their offspring and to prevent the devastating and permanent consequences of cretinism in domestic animal populations.

293. (B) Parathyroid hormone (PTH)
Calcitriol, the active hormonal form of Vitamin D, is essential for maintaining systemic calcium and phosphate homeostasis. Its synthesis in the kidney is a tightly regulated process that occurs in response to the body's mineral needs. The final step of this synthesis, which involves the conversion of 25-hydroxycholecalciferol into 1,25-dihydroxycholecalciferol, is catalyzed by the enzyme 1-alpha-hydroxylase. This enzyme is directly and potently stimulated by parathyroid hormone. When blood calcium levels fall, the parathyroid glands release PTH, which then travels to the kidneys and increases the activity of 1-alpha-hydroxylase. this result in a rapid increase in the production of calcitriol, which travels to the intestine and bone to promote calcium absorption and mobilization. This hormonal interaction ensures a coordinated and effective response to hypocalcemia, linking the parathyroid glands' sensing of calcium to the final activation of the Vitamin D pathway in the kidneys. By regulating this enzyme, PTH serves as the primary biochemical driver of calcitriol synthesis in mammals.

294. (C) UDP-glucuronosyltransferase
Bilirubin is a yellow pigment produced from the degradation of heme that must be chemically modified for efficient excretion. In the liver, unconjugated bilirubin is taken up by hepatocytes and transported to the endoplasmic reticulum. The primary biochemical process for its modification is conjugation with glucuronic acid. This reaction is catalyzed by the specific enzyme UDP-glucuronosyltransferase. UGT transfers a glucuronic acid moiety from the donor molecule UDP-glucuronic acid to the bilirubin, forming bilirubin monoglucuronide and subsequently bilirubin diglucuronide. This conjugation significantly increases the water solubility of the bilirubin and reduces its toxicity, allowing it to be effectively secreted into the bile canaliculi for elimination in the feces. The activity of UGT is a critical step in bilirubin metabolism, and its impairment can lead to the accumulation of unconjugated bilirubin in the blood, manifesting as jaundice. This pathway represents a key hepatic detoxification mechanism for maintaining systemic pigment balance in domestic and wild animals.

295. (D) Total body muscle mass
Creatinine is a metabolic byproduct that serves as a standard clinical marker for assessing renal function. It is derived entirely from the spontaneous and non-enzymatic dehydration of muscle creatine and creatine phosphate. Because this conversion occurs at a remarkably constant rate within the muscle cells, the total daily production of creatinine is directly proportional to the animal's total body muscle mass. Unlike blood urea nitrogen, which is influenced by dietary protein intake, serum creatinine levels are very stable in an individual and reflect the constant turnover of muscle energy stores. This relationship makes creatinine a reliable indicator of the glomerular filtration rate, as the kidneys must filter the constant supply of creatinine from the blood. However, clinicians must consider the animal's muscle mass when interpreting results, as a very muscular animal will naturally have higher baseline creatinine levels than a smaller or more debilitated individual, highlighting the importance of muscle mass in the biochemistry of renal markers.

296. (A) Albumin
The urine dipstick is a common and convenient diagnostic tool for the qualitative detection of various substances, including protein. The principle of the protein test on a dipstick relies on a chemical phenomenon known as the "protein error of indicators." Certain pH indicators will change color in the presence of protein, even when the pH of the solution remains constant. This reaction is most exquisitely sensitive to albumin, which is the most abundant protein in the blood and the one most likely to be found in pathological urine due to glomerular damage. While the dipstick can detect other proteins, its sensitivity to globulins or specialized proteins like

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generally improve column resolution.

Which of the above statement(s) is/are correct?

(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2010

33. In gas chromatography, which carrier gas is generally preferred for its inertness and safety, despite a slightly lower efficiency than hydrogen?

(A) Oxygen
(B) Helium
(C) Carbon dioxide
(D) Methane

2010

34. In affinity chromatography, how are the specifically bound proteins typically eluted from the column?

(A) Washing the column with pure deionized water.
(B) High concentration of free ligand or pH alteration.
(C) Increasing the internal column temperature.
(D) Applying high hydrostatic column pressure.

2014

35. Match the items in List I with those in List II.

List I: (Buffer or Reagent)

P. SDS
Q. β-mercaptoethanol
R. TEMED
S. Bromophenol blue

List II: (Function)

1. Reduces disulfide bonds
2. Catalyzes the polymerization of acrylamide
3. Imparts a uniform negative charge to proteins
4. Acts as a tracking dye during the run

(A) P-III, Q-I, R-II, S-IV
(B) P-I, Q-III, R-IV, S-II
(C) P-III, Q-II, R-I, S-IV
(D) P-IV, Q-I, R-III, S-II

2016

36. Which statement is an INCORRECT description of two-dimensional (2D) gel electrophoresis?

(A) It resolves complex protein mixtures better than 1D SDS-PAGE.
(B) The first dimension separates proteins based on molecular weight.
(C) The second dimension typically utilizes SDS-PAGE.
(D) Ampholytes are crucial for establishing the pH gradient in the first step.

2019

37. Which detector is most appropriate for monitoring high-energy gamma radiation?

(A) Liquid scintillation counter
(B) Autoradiography film
(C) Geiger-Müller counter equipped with a thick-walled tube
(D) Solid-state scintillation detector (NaI crystal)

2003

38. When extracting plasmid DNA using the alkaline lysis method, what is the role of potassium acetate?

(A) To lyse the bacterial cell wall
(B) To denature the genomic DNA
(C) To neutralize the pH and precipitate genomic DNA and proteins
(D) To selectively degrade RNA

2001

39. Which metric is most relevant for assessing carbohydrate or guanidine carryover in a nucleic acid sample via spectrophotometry?

(A) $\frac{A_{260}}{A_{280}}$ ratio

(B) $\frac{A_{260}}{A_{230}}$ ratio

(C) $\frac{A_{280}}{A_{230}}$ ratio

(D) Absorbance at 320 nm

2006

40. Given below are statements regarding RT-PCR:

I. It requires the enzyme reverse transcriptase to synthesize cDNA.
II. It amplifies RNA directly without a DNA intermediate.
III. It can be used to quantify viral RNA loads in clinical samples.
IV. Oligo(dT) primers are often used to target eukaryotic mRNA.

Which of the above statement(s) is/are correct?

(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

2006

41. Restriction enzymes with "star activity" exhibit what problematic behavior?

(A) Inability to cut methylated DNA
(B) Cleavage of DNA at non-canonical recognition

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(A) I, II, III, IV
(B) II, I, III, IV
(C) III, I, II, IV
(D) II, III, I, IV

2014

23. Which clinical enzyme is considered the most liver-specific indicator of hepatocellular damage in dogs and cats?
(A) Aspartate aminotransferase (AST)
(B) Creatine kinase (CK)
(C) Alkaline phosphatase (ALP)
(D) Alanine aminotransferase (ALT)

2004

24. From a biochemical diagnostic perspective, an elevation in both Blood Urea Nitrogen (BUN) and serum creatinine most strongly infers dysfunction in which organ?
(A) Kidney
(B) Liver
(C) Pancreas
(D) Thyroid

2006

25. Which diagnostic immunoassay is most relevant for identifying primary hypothyroidism in domestic animals?
(A) Measurement of elevated cortisol levels
(B) Measurement of low serum total T_4 and high TSH
(C) Measurement of elevated blood insulin levels
(D) Measurement of decreased parathyroid hormone

2009

26. In UV-Visible spectrophotometry, deviations from the Beer-Lambert law can occur due to which factor?
(A) Extremely low concentration of the analyte
(B) Using a monochromatic light source
(C) Constant path length
(D) Stray light reaching the detector

2023

27. What is the fundamental difference between flame photometry and Atomic Absorption Spectroscopy (AAS)?
(A) Flame photometry measures emission; AAS measures absorption.
(B) Flame photometry uses hollow cathodes; AAS uses laser light.
(C) Flame photometry is for metals; AAS is for organic gases.
(D) Flame photometry uses X-rays; AAS uses gamma radiation.

NODIA

2006

28. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Differential pelleting is used to separate sub-cellular organelles based on their sedimentation coefficients.
Reason (R): Larger and denser particles sediment faster at a given centrifugal force than smaller, less dense particles.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

29. Which cell disruption technique relies on cavitation bubbles produced by high-frequency sound waves?
(A) Osmotic shock
(B) Bead milling
(C) Ultrasonication
(D) Dounce homogenization

2005

30. During protein dialysis, the speed of salt removal can be increased by which method?
(A) Decreasing the surface area of the dialysis tubing
(B) Increasing the volume of the retentate
(C) Frequently changing the surrounding buffer solution
(D) Using a membrane with a much smaller molecular weight cutoff

2014

31. Which protein assay exhibits the least protein-to-protein variation due to its reliance on peptide bonds rather than specific amino acid side chains?
(A) Bradford assay
(B) Lowry assay
(C) Biuret assay
(D) UV absorbance at 280 nm

2001

32. Given below are statements regarding High-Performance Liquid Chromatography (HPLC):
I. Reverse-phase HPLC utilizes a non-polar stationary phase and a polar mobile phase.
II. Isocratic elution involves changing the mobile phase composition over time.
III. Smaller particle sizes in the stationary phase

(A) Tyndall effect
(B) Stokes shift
(C) Raman scattering
(D) Rayleigh scattering

2018

52. Which interference in flame photometry occurs when atoms in the flame absorb the emitted radiation from other atoms of the same element?
(A) Ionization interference
(B) Chemical interference
(C) Self-absorption interference
(D) Spectral interference

2024

53. Match the items in List I with those in List II.
List I: (Centrifugation Parameter)
P. RPM
Q. RCF
R. Nomogram
S. Sedimentation coefficient
List II: (Definition)
1. The ratio of a particle's sedimentation velocity to the applied acceleration
2. Revolutions per minute of the rotor
3. A graphical calculating device used to convert between speed and relative centrifugal force
4. The force exerted on particles during centrifugation, expressed in units of gravity (g)
(A) P-II, Q-IV, R-III, S-I
(B) P-IV, Q-II, R-I, S-III
(C) P-II, Q-I, R-IV, S-III
(D) P-III, Q-IV, R-II, S-I

2002

54. When extracting enzymes from plant tissues, which additive is commonly included in the homogenization buffer to inhibit polyphenolooxidases and prevent browning?
(A) SDS
(B) EDTA
(C) Polyvinylpyrrolidone (PVP)
(D) Sodium azide

2018

55. What is the primary chemical principle behind protein precipitation using trichloroacetic acid (TCA)?
(A) It disrupts the hydration shell and denatures the protein, leading to aggregation.
(B) It specifically binds to active sites, causing reversible inhibition.
(C) It increases the dielectric constant of the solution.
(D) It cleaves peptide bonds uniformly.

2021

56. Given below are statements regarding the BCA protein assay:
I. It involves the reduction of Cu^{2+} to Cu^{1+} by proteins in an alkaline medium.
II. The Cu^{1+} ion forms a purple complex with bicinchoninic acid.
III. The assay is read at an absorbance of 280 nm.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2002

57. In anion-exchange chromatography, how is the charge of the protein analytes manipulated to ensure binding to the positively charged column matrix?
(A) The buffer pH is set below the proteins' isoelectric points (pI).
(B) The buffer pH is set above the proteins' isoelectric points (pI).
(C) A high concentration of sodium chloride is added.
(D) Non-ionic detergents are added to the buffer.

2006

58. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): High-Performance Liquid Chromatography (HPLC) operates at much higher pressures than traditional column chromatography.
Reason (R): The stationary phase in HPLC consists of very small particle sizes, which generate high resistance to mobile phase flow.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

59. In gel filtration chromatography, the total volume of the column (V_t) is equal to the sum of the void volume (V_o) and the internal pore volume (V_i). Where do molecules that are larger than the pore exclusion limit elute?

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(A) At the internal volume (V_i)
(B) At the total volume (V_t)
(C) At the void volume (V_o)
(D) They do not elute and remain on the column

2024

60. The electrophoretic mobility of a nucleic acid in an agarose gel is inversely proportional to which of its properties?
(A) Net negative charge
(B) Purine to pyrimidine ratio
(C) Logarithm of its molecular weight
(D) Melting temperature (T_m)

2008

61. Identify the INCORRECT statement regarding 2D gel electrophoresis.
(A) It is a standard technique in top-down and bottom-up proteomics.
(B) Post-translational modifications can result in a train of distinct spots for a single protein.
(C) Proteins separate by pI in the first dimension.
(D) The second dimension involves native, non-denaturing conditions.

2001

62. Which metric defines the time required for half of the radioactive atoms in a specific sample to undergo decay?
(A) Specific activity
(B) Half-life
(C) Decay constant
(D) Quantum yield

2017

63. During RNA extraction, what is the primary purpose of adding guanidinium thiocyanate to the lysis buffer?
(A) To precipitate RNA selectively
(B) To permanently inactivate endogenous RNases
(C) To act as a colorimetric indicator of pH
(D) To stabilize double-stranded DNA structures

2007

64. A purified DNA sample has an absorbance of 1.0 at 260 nm using a standard 1 cm cuvette. What is the approximate concentration of double-stranded DNA in the sample?
(A) 20 µg/mL
(B) 33 µg/mL
(C) 40 µg/mL
(D) 50 µg/mL

2011

65. Match the items in List I with those in List II.
List I: (PCR Variant)
P. Nested PCR
Q. Multiplex PCR
R. Reverse Transcriptase PCR
S. Real-time PCR (qPCR)
List II: (Application)
1. Simultaneous amplification of multiple different targets in a single tube
2. Increased specificity by using two sets of primers in successive reactions
3. Continuous monitoring of amplicon accumulation using fluorescent dyes
4. Amplification of cDNA synthesized from an RNA template
(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-III, S-IV
(C) P-II, Q-III, R-IV, S-I
(D) P-III, Q-I, R-IV, S-II

NODIA

2015

66. Which enzyme is essential for generating the specific fragments analyzed in an RFLP assay?
(A) DNA ligase
(B) Restriction endonuclease
(C) Reverse transcriptase
(D) DNA helicase

2012

67. Given below are statements regarding microsatellites:
I. They are typically composed of repeat units 2-6 base pairs in length.
II. They are highly polymorphic across populations.
III. They are dispersed evenly throughout the prokaryotic genome but absent in eukaryotes.
IV. They are widely used for parentage verification in animal breeding.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2010

68. Select the correct sequence of probe hybridization kinetics.
I. Probe binding, stringency washes to remove non-specific binding, detection
II. Stringency washes, probe binding, detection
III. Detection, stringency washes, probe binding
IV. Probe binding, detection, stringency washes
(A) I

(B) II
(C) III
(D) IV

2017

69. Which specific sequence element is required in a plasmid vector to allow it to replicate autonomously within a bacterial host cell?
(A) Multiple cloning site (MCS)
(B) Selectable marker gene
(C) Origin of replication (ori)
(D) Promoter sequence

2023

70. What is the primary advantage of a sandwich ELISA over a direct ELISA?
(A) It requires only a single antibody.
(B) It offers higher specificity since two distinct antibodies must bind the antigen.
(C) It does not require any washing steps.
(D) It relies on radioactive isotopes rather than enzymes.

2018

71. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): DNA microarrays can simultaneously analyze the expression levels of thousands of genes.
Reason (R): Microarrays utilize immobilized arrays of specific nucleic acid probes that hybridize to fluorescently labeled target cDNA.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

72. Which type of nanoparticle is renowned for its size-tunable fluorescence emission, making it highly valuable in advanced biological imaging?
(A) Fullerenes
(B) Quantum dots
(C) Liposomes
(D) Solid lipid nanoparticles

2006

73. In clinical enzymology, an isolated increase in serum Alkaline Phosphatase (ALP) in a growing puppy is most likely indicative of:
(A) Severe hepatic necrosis
(B) Normal bone osteoblast activity
(C) Acute pancreatitis
(D) Renal failure

2025

74. Which metabolite provides the most accurate estimation of the Glomerular Filtration Rate (GFR) because it is freely filtered and not significantly reabsorbed by the renal tubules?
(A) Urea
(B) Uric acid
(C) Creatinine
(D) Ammonia

2017

75. Given below are statements regarding vitamin diagnostics:
I. Vitamin E deficiency in calves is associated with white muscle disease.
II. Vitamin B_{12} absorption requires intrinsic factor produced in the stomach.
III. Biotin is a water-soluble vitamin essential for carboxylation reactions.
IV. Vitamin D levels are assessed by measuring serum 1,25-dihydroxycholecalciferol exclusively.
V. Vitamin K is essential for the synthesis of prothrombin.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) IV only
(C) III and V
(D) II and III

2021

76. In fluorimetry, inner filter effects can lead to non-linear calibration curves. What primarily causes this phenomenon?
(A) Photobleaching of the fluorophore over time
(B) Absorption of the excitation or emission light by the sample itself at high concentrations
(C) The use of a photomultiplier tube as a detector
(D) Scattering of light by dust particles in the cuvette

2001

77. Which flame in flame photometry provides the highest temperature, making it suitable for elements that are difficult to atomize?
(A) Air-propane
(B) Air-acetylene
(C) Nitrous oxide-acetylene
(D) Oxygen-hydrogen

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2. 260 nm
3. 230 nm
4. 320 nm

(A) P-II, Q-I, R-IV, S-III
(B) P-I, Q-II, R-III, S-IV
(C) P-II, Q-I, R-III, S-IV
(D) P-I, Q-II, R-IV, S-III

2010

115. What limits the maximum size of a DNA amplicon that can be efficiently amplified by standard PCR?
(A) The concentration of the primers
(B) Processivity and half-life of Taq polymerase.
(C) The melting temperature of the template DNA
(D) The size of the thermal cycler block

2001

116. Which specific molecular change cannot be directly detected by standard Restriction Fragment Length Polymorphism (RFLP) analysis?
(A) A single base substitution within the restriction enzyme's recognition site
(B) A large insertion between two restriction sites
(C) A large deletion between two restriction sites
(D) A silent mutation in an exon that does not alter any restriction site

2011

117. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Microsatellites are preferred over minisatellites for modern DNA profiling.
Reason (R): Microsatellites have shorter repeating units, making them highly suitable for robust amplification via multiplex PCR, even from degraded DNA.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

118. In Northern blotting, formaldehyde or glyoxal is typically added to the agarose gel. What is their specific function?
(A) To cross-link the RNA to the membrane
(B) To denature RNA and prevent the formation of secondary structures
(C) To act as a colorimetric indicator of pH
(D) To inhibit RNase enzymes

2005

119. Given below are statements regarding bacteriophage lambda vectors:
I. They can accommodate larger DNA inserts than standard plasmid vectors.
II. The recombinant DNA is packaged into phage heads in vitro.
III. They infect bacterial cells via transduction.
IV. They are exclusively used for cloning eukaryotic mRNA.
V. They utilize the lytic cycle to generate plaques on a bacterial lawn.
Which of the above statement(s) is/are correct?
(A) I, II, III and V
(B) II, III, IV and V
(C) I, III, IV and V
(D) I, II, III, IV and V

2024

120. Which parameter fundamentally dictates the sensitivity of a Radioimmunoassay (RIA)?
(A) The half-life of the isotope
(B) The affinity constant of the specific antibody
(C) The volume of the assay tube
(D) The speed of the gamma counter

NODIA

2004

121. In proteomics, what is the primary role of trypsin prior to LC-MS analysis in a "bottom-up" approach?
(A) It stabilizes the intact protein structures.
(B) It cleaves proteins specifically at the C-terminal side of lysine and arginine residues to generate peptides.
(C) It acts as a standard for molecular weight calibration.
(D) It ionizes the proteins for mass spectrometry.

2006

122. Which potential application of nanotechnology in veterinary medicine poses the greatest theoretical risk of bioaccumulation?
(A) In vitro diagnostic nanosensors
(B) Biodegradable liposomal drug delivery systems
(C) Persistent metallic nanoparticles used as systemic imaging contrast agents
(D) Nanofiber wound dressings

(D) Ammonium persulfate (APS)

2021

87. What is the fundamental principle of measuring radioactivity with a Geiger-Müller (GM) counter?
(A) Detection of light flashes emitted when radiation strikes a crystal
(B) Ionization of a gas within a sealed tube by incoming radiation
(C) Measurement of the heat generated by radioactive decay
(D) Photographic emulsion darkening

2003

88. Order the sequence of steps for typical RNA purification from tissue.
I. Precipitation with isopropanol
II. Homogenization in a denaturing lysis buffer
III. Phase separation using chloroform
IV. Washing the pellet with 75% ethanol
(A) II, III, I, IV
(B) II, I, III, IV
(C) III, II, I, IV
(D) I, II, III, IV

2025

89. In UV spectrophotometric assessment of nucleic acids, a prominent absorbance peak at 230 nm usually indicates contamination by:
(A) Proteins
(B) Phenolate ions or chaotropic salts
(C) Ethidium bromide
(D) Carbohydrates

2008

90. Which PCR component dictates the specific region of the template DNA that will be amplified?
(A) Taq polymerase
(B) Deoxynucleotide triphosphates (dNTPs)
(C) Magnesium chloride
(D) Oligonucleotide primers

2023

91. Match the items in List I with those in List II.
List I: (Cut Style)
P. EcoRI
Q. SmaI
R. PstI
S. BamHI
List II: (DNA Ends)
1. Blunt ends
2. 5' cohesive (sticky) ends
3. 3' cohesive (sticky) ends
4. 5' cohesive (sticky) ends (distinct from II)
(A) P-II, Q-I, R-III, S-IV
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-I, R-II, S-IV
(D) P-II, Q-III, R-I, S-IV

2008

92. Identify the INCORRECT statement regarding DNA fingerprinting in veterinary forensics.
(A) It can definitively prove the exact age of an animal.
(B) It is used to identify poached wildlife remains.
(C) It relies on analyzing highly polymorphic genomic regions.
(D) It can resolve parentage disputes in pedigree registries.

2006

93. What critical step must precede the transfer of DNA to a membrane in Southern blotting if large DNA fragments (> 10 kb) are to be transferred efficiently?
(A) Neutralization with Tris buffer
(B) Depurination with dilute HCl
(C) Digestion with RNase A
(D) Staining with silver nitrate

2011

94. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Expression vectors differ from standard cloning vectors because they contain specific regulatory sequences.
Reason (R): Regulatory sequences like promoters and Ribosome Binding Sites (RBS) are essential to drive the transcription and translation of the inserted gene in the host cell.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

95. In an indirect ELISA for detecting antibodies in a patient's serum, what is coated on the surface of the microtiter plate well?
(A) The enzyme-linked secondary antibody
(B) The specific target antigen
(C) The patient's serum
(D) A generic blocking buffer protein

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2025

96. In MALDI-TOF mass spectrometry, what does the "TOF" stand for, which defines how the ionized molecules are separated?
(A) Temperature of Fusion
(B) Time of Flight
(C) Tandem Orthogonal Focusing
(D) Total Output Frequency

2016

97. Given below are statements regarding nanotechnology in diagnostics:
I. Nanoparticles have a high surface-area-to-volume ratio.
II. Magnetic nanoparticles can be used to concentrate pathogens from biological samples.
III. Nanomaterials invariably lack toxicity and are universally biocompatible.
IV. Gold nanoparticles display localized surface plasmon resonance.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) II, III and IV
(C) I, II and III
(D) I, III and IV

2013

98. Increased serum levels of Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST) usually indicate injury to which subcellular components?
(A) Cytosol and mitochondria
(B) Nucleus and ribosomes
(C) Golgi apparatus and lysosomes
(D) Smooth endoplasmic reticulum only

2002

99. Which physiological or pathological state is most likely to cause a pre-renal elevation of Blood Urea Nitrogen (BUN)?
(A) Ruptured urinary bladder
(B) Dehydration causing reduced renal perfusion
(C) Primary renal tubular necrosis
(D) Urethral obstruction by a calculus

2005

100. A low serum calcium level combined with a high serum phosphorus level in a dog with chronic kidney disease points to dysfunction of which endocrine axis?
(A) Hypothalamic-Pituitary-Adrenal axis
(B) Renin-Angiotensin-Aldosterone system
(C) Parathyroid hormone and Vitamin D regulation
(D) Thyroid hormone synthesis

2009

101. Which component of a UV-Visible spectrophotometer isolates a specific narrow band of wavelengths from the broad-spectrum light source?
(A) Photodetector
(B) Monochromator
(C) Cuvette holder
(D) Amplifier

2015

102. What type of samples must be utilized when analyzing elements via flame photometry?
(A) Solid metal ingots
(B) Lyophilized powders exclusively
(C) Liquid solutions or fine suspensions aerosolized into the flame
(D) Frozen tissue sections

NODIA

2008

103. Match the items in List I with those in List II.
List I: (Centrifugation Technique)
P. Differential centrifugation
Q. Rate-zonal centrifugation
R. Isopycnic centrifugation
S. Analytical ultracentrifugation
List II: (Application)
1. Separation based strictly on buoyant density, independent of time
2. Crude fractionation of cell homogenates into nuclear, mitochondrial, and cytosolic pellets
3. Separation based on size/mass through a pre-formed density gradient
4. Precise determination of molecular weight and hydrodynamic properties of macromolecules
(A) P-II, Q-III, R-I, S-IV
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-I, R-IV, S-II
(D) P-II, Q-IV, R-I, S-III

2014

104. Which of the following is NOT a mechanical method of cell disruption?
(A) Homogenization with a Potter-Elvehjem grinder
(B) Sonication
(C) Osmotic lysis
(D) Bead milling

2018

105. During ultrafiltration, what phenomenon reduces the filtration rate due to the accumulation of retained macrosolutes on the membrane surface?
(A) Concentration polarization
(B) Reverse osmosis

(C) Capillary action
(D) Donnan effect

2003

106. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): The BCA assay can be reliably performed on samples containing up to 5% SDS.
Reason (R): Unlike the Lowry assay, the BCA reagent is highly tolerant to ionic detergents.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

107. In thin-layer chromatography (TLC), how is the Retention factor (R_f) calculated?
(A) $\frac{\text{Distance traveled by solvent}}{\text{Distance traveled by solute}}$
(B) $\frac{\text{Distance traveled by solute}}{\text{Distance traveled by solvent front}}$
(C) $\frac{\text{Volume of mobile phase}}{\text{Volume of stationary phase}}$
(D) $\frac{\text{Time taken by solute}}{\text{Time taken by solvent}}$

2009

108. Order the general components of an HPLC system from solvent reservoir to waste.
I. Analytical column
II. Pump
III. Detector
IV. Sample injector
(A) II, IV, I, III
(B) IV, II, I, III
(C) II, I, IV, III
(D) I, II, III, IV

2009

109. Given below are statements regarding gel filtration matrices:
I. Sephadex is a cross-linked dextran gel.
II. Polyacrylamide gels (Bio-Gel P) are used for size exclusion.
III. Agarose gels (Sepharose) have small pores and are only for small peptides.
IV. The degree of cross-linking determines the fractionation range.
Which of the above statement(s) is/are INCORRECT?
(A) III only
(B) I and II
(C) II and IV
(D) I and IV

2003

110. In agarose gel electrophoresis of DNA, what is the primary function of ethidium bromide?
(A) It increases the density of the sample for well loading.
(B) It maintains the pH of the running buffer.
(C) It intercalates between base pairs and fluoresces under UV light for visualization.
(D) It actively pushes the DNA towards the positive electrode.

NODIA

2024

111. During Isoelectric Focusing (IEF), what happens to a protein when it reaches the pH zone corresponding to its isoelectric point?
(A) It denatures completely.
(B) Its net charge becomes zero and it stops migrating.
(C) It reverses its direction of migration.
(D) It gets degraded by proteases.

2021

112. In liquid scintillation counting, what is the role of the primary fluor?
(A) To absorb beta-particle energy from the solvent and emit light photons.
(B) To shield the sample from cosmic background radiation.
(C) To dissolve the biological sample completely.
(D) To shift the emitted wavelength to a higher energy level.

2004

113. Which enzyme is commonly added during genomic DNA extraction to specifically eliminate RNA contamination?
(A) Proteinase K
(B) DNase I
(C) RNase A
(D) Lysozyme

2018

114. Match the items in List I with those in List II.
List I: (Nucleic Acid Property)
P. Peak absorbance of pure DNA
Q. Peak absorbance of pure proteins
R. Background scatter / turbidity correction
S. Assessment of organic solvent contamination
List II: (Standard Reading)
1. 280 nm

2018

78. In a fixed-angle centrifuge rotor, where do the pelleted particles accumulate?
(A) Evenly across the entire bottom of the tube
(B) Along the inner side wall of the tube
(C) At the outermost bottom corner of the tube
(D) Suspended in the middle of the gradient

2023

79. Match the items in List I with those in List II.
List I: (Disruption Method)
P. Lysozyme
Q. Detergent lysis
R. Bead beating
S. French press
List II: (Principle or Target)
1. Mechanical shearing of tough yeast or fungal cell walls using microparticles
2. Enzymatic degradation of bacterial peptidoglycan
3. High-pressure extrusion causing rapid decompression and cell bursting
4. Solubilization of lipid bilayers and membrane proteins
(A) P-II, Q-IV, R-I, S-III
(B) P-IV, Q-II, R-III, S-I
(C) P-I, Q-III, R-II, S-IV
(D) P-II, Q-I, R-IV, S-III

2016

80. When concentrating a protein solution using ultrafiltration, the membrane's Molecular Weight Cut-Off (MWCO) should ideally be:
(A) Twice the molecular weight of the target protein
(B) Equal to the molecular weight of the target protein
(C) Approximately half to one-third the molecular weight of the target protein
(D) Ten times the molecular weight of the target protein

2013

81. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): The Bradford assay is incompatible with samples containing high concentrations of detergents like Triton X-100.
Reason (R): Detergents can precipitate the Coomassie Brilliant Blue dye, leading to erroneously high absorbance readings.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

82. In chromatography, the term "Resolution (Rs)" refers to what specific metric?
(A) The speed at which the mobile phase travels
(B) The degree of separation between two adjacent peaks on the chromatogram
(C) The total number of theoretical plates in the column
(D) The volume of mobile phase required to elute the first peak

2009

83. Which detector used in Gas Chromatography (GC) is essentially non-destructive, allowing for the recovery of analytes after detection?
(A) Flame Ionization Detector (FID)
(B) Electron Capture Detector (ECD)
(C) Thermal Conductivity Detector (TCD)
(D) Mass Spectrometer (MS)

2016

84. Given below are statements regarding Affinity Chromatography:
I. It relies on reversible biological interactions, such as enzyme-substrate binding.
II. A spacer arm is often attached to the matrix to prevent steric hindrance.
III. Elution is typically achieved by washing with a buffer identical to the binding buffer.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2025

85. During Native PAGE, proteins are separated based on which physical properties?
(A) Only molecular weight
(B) Only net charge
(C) Molecular weight, net charge, and physical shape
(D) Hydrophobicity alone

2005

86. Which chemical serves as a reducing agent in SDS-PAGE to break intra- and inter-molecular disulfide bonds?
(A) Sodium dodecyl sulfate
(B) Dithiothreitol (DTT)
(C) Coomassie blue

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2009

123. The enzyme Creatine Kinase (CK) exists as different isoenzymes. Which isoenzyme fraction is predominantly found in cardiac muscle?
(A) CK-MM
(B) CK-MB
(C) CK-BB
(D) CK-Mt

2022

124. Order the progression of metabolic changes typically observed during uncontrolled severe diabetic ketoacidosis.
I. Hyperglycemia due to insulin lack
II. Increased lipolysis and free fatty acid release
III. Hepatic conversion of fatty acids to ketone bodies
IV. Systemic metabolic acidosis
(A) I, II, III, IV
(B) II, I, III, IV
(C) I, III, II, IV
(D) II, III, I, IV

2007

125. Match the items in List I with those in List II.
List I: (Endocrine Hormone)
P. Parathyroid Hormone (PTH)
Q. Cortisol
R. Aldosterone
S. Insulin
List II: (Regulatory Function)
1. Regulates sodium retention and potassium excretion
2. Lowers blood glucose levels by promoting cellular uptake
3. Mobilizes calcium from bone to increase blood calcium levels
4. Mediates stress response and promotes gluconeogenesis
(A) P-III, Q-IV, R-I, S-II
(B) P-IV, Q-III, R-I, S-II
(C) P-III, Q-I, R-IV, S-II
(D) P-I, Q-IV, R-III, S-II

2008

126. A hyperchromic shift in UV spectrophotometry refers to:
(A) An increase in absorption intensity at a constant wavelength
(B) A shift in the absorption maximum to a longer wavelength
(C) A decrease in absorption intensity
(D) A shift in the absorption maximum to a shorter wavelength

2004

127. Which flame photometry component is responsible for breaking the liquid sample into fine droplets before it enters the flame?
(A) Monochromator
(B) Photomultiplier
(C) Nebulizer
(D) Chopper

2005

128. In centrifugation, the clearing factor (k-factor) of a rotor is an index of:
(A) The physical strength of the rotor material
(B) The pelleting efficiency of the rotor
(C) The maximum volume the rotor can hold
(D) The rate at which the rotor cools down

NQDIA

2001

129. When homogenizing liver tissue for the isolation of active mitochondria, which buffer condition is absolutely essential?
(A) Hypertonic saline
(B) Isotonic sucrose or mannitol medium
(C) Distilled water
(D) High concentration of SDS

2007

130. Given below are statements regarding dialysis:
I. It is driven by the concentration gradient across the membrane.
II. It is a rapid process, typically completing within minutes.
III. The membrane allows passage of macromolecules but retains small ions.
Which of the above statement(s) is/are INCORRECT?
(A) II and III
(B) I only
(C) III only
(D) I and II

2004

131. Which amino acid residues are primarily responsible for the reduction of the Folin-Ciocalteu reagent in the Lowry protein assay?
(A) Alanine and Glycine
(B) Tyrosine and Tryptophan
(C) Serine and Threonine
(D) Valine and Leucine

2012

132. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): In ion-exchange chromatography,

proteins can be eluted by gradually increasing the salt concentration of the mobile phase.
Reason (R): Salt ions (like Na^+ and Cl-) compete with the charged proteins for binding sites on the stationary phase matrix.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

133. In gas chromatography, tailing of peaks is most commonly caused by:
(A) Injection of too small a sample volume
(B) Strong, irreversible interactions between the analyte and active sites on the column
(C) Extremely high carrier gas flow rates
(D) Using a completely non-polar stationary phase for non-polar compounds

2002

134. Which specific ligand is coupled to the matrix in immobilized metal affinity chromatography (IMAC) for the purification of His-tagged recombinant proteins?
(A) Glutathione
(B) Nickel or Cobalt ions
(C) Protein A
(D) Concanavalin A

2006

135. During SDS-PAGE, proteins migrate towards which electrode?
(A) The negative electrode (cathode)
(B) The positive electrode (anode)
(C) They do not migrate but remain stationary
(D) They migrate sideways towards the cooling chamber

2016

136. Match the items in List I with those in List II.
List I: (Electrophoretic Technique)
P. Pulse-field gel electrophoresis (PFGE)
Q. Capillary electrophoresis
R. Isoelectric focusing
S. 2D-PAGE
List II: (Defining Feature)
1. Uses alternating electric fields to resolve megabase-sized DNA
2. Separates proteins based on pI using ampholytes
3. Employs narrow fused-silica tubes for high-resolution, rapid separation
4. Combines pI separation with molecular weight separation
(A) P-I, Q-III, R-II, S-IV
(B) P-III, Q-I, R-II, S-IV
(C) P-I, Q-II, R-III, S-IV
(D) P-IV, Q-III, R-I, S-II

2018

137. Which radioactive isotope is a pure gamma emitter and is commonly used to label proteins, especially antibodies, for RIA?
(A) Tritium ($14C$)
(B) Carbon-14 (^{14}C)
(C) Iodine-125 (^{125}I)
(D) Phosphorus-32 (^{32}P)

2002

138. Consider the following steps for plasmid DNA extraction via alkaline lysis:
I. Resuspension of bacterial pellet
II. Addition of NaOH/SDS lysis buffer
III. Addition of neutralizing potassium acetate
IV. Centrifugation to remove genomic DNA and debris
V. Precipitation of plasmid DNA with alcohol
Which combination represents the correct chronological order?
(A) I, II, III, IV, V
(B) II, I, III, IV, V
(C) I, III, II, IV, V
(D) II, III, I, V, IV

2013

139. If a DNA sample is severely contaminated with phenol, what effect does this have on the $\frac{A_{260}}{A_{280}}$ ratio?
(A) The ratio will artificially increase well above 2.0.
(B) The ratio will falsely decrease, often below 1.5.
(C) The ratio will remain exactly 1.8.
(D) The absorbance at 260 nm becomes zero.

2011

140. Which modification in a qPCR assay specifically ensures that the fluorescent signal is generated only when the specific target sequence is amplified, rather than from any double-stranded DNA?
(A) Using SYBR Green dyes to detect all double strands.
(B) Using TaqMan probes with a fluorophore and quencher.
(C) Increasing the concentration of specific

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primers.
(D) Significantly lowering the annealing temperature.

2007

141. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): RFLP analysis was largely replaced by PCR-based microsatellite analysis in modern forensic and genetic laboratories.
Reason (R): RFLP requires large quantities of high-molecular-weight DNA and is a more time-consuming process involving Southern blotting.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

142. The term "VNTR" stands for:
(A) Variable Nucleotide Tandem Repeats
(B) Variable Number of Tandem Repeats
(C) Varied Normal Terminal Repeats
(D) Viral Nucleotide Transcription Regions

2010

143. In nucleic acid hybridization, what is the effect of decreasing the salt concentration (e.g., SSC buffer) during the washing steps?
(A) It decreases the stringency, allowing mismatched probes to remain bound.
(B) It increases the stringency, washing away weakly bound, mismatched probes.
(C) It degrades the target DNA.
(D) It causes the probe to fluoresce more brightly.

2009

144. Match the items in List I with those in List II.
List I: (Vector Type)
P. Plasmid
Q. Bacteriophage Lambda
R. Cosmid
S. YAC (Yeast Artificial Chromosome)
List II: (Maximum Insert Capacity)
1. ~10 kb
2. ~20-25 kb
3. ~35-45 kb
4. Up to 1000 kb+
(A) P-I, Q-II, R-III, S-IV
(B) P-II, Q-I, R-III, S-IV
(C) P-I, Q-III, R-II, S-IV
(D) P-IV, Q-III, R-II, S-I

2009

145. In an ELISA, what is the function of the "blocking" step, typically performed using BSA or non-fat dry milk?
(A) To stop the enzymatic color reaction
(B) To prevent non-specific binding of antibodies to the plastic well surface
(C) To lyse any bacteria in the sample
(D) To covalently cross-link the antigen to the plate

2019

146. Which omics technology relies heavily on the use of labeled complementary DNA (cDNA) hybridized to hundreds of thousands of microscopic spots of specific oligonucleotides?
(A) Transcriptomics via DNA microarrays
(B) Proteomics via LC-MS
(C) Metabolomics via NMR
(D) Genomics via Sanger sequencing

2023

147. Given below are statements regarding nanoparticle delivery systems:
I. Liposomes are spherical vesicles composed of lipid bilayers.
II. They can encapsulate hydrophilic drugs in their aqueous core.
III. They can incorporate hydrophobic drugs within the lipid bilayer.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I and II
(C) I and III
(D) II and III

2001

148. Which factor is considered a common non-hepatic cause for elevated serum Alkaline Phosphatase (ALP) in adult dogs?
(A) Exogenous or endogenous corticosteroids (e.g., Cushing's disease)
(B) High-protein diet
(C) Dehydration
(D) Vitamin C deficiency

2003

149. In ruminants, the measurement of which parameter is a more reliable indicator of energy balance and early subclinical ketosis than blood glucose?
(A) Serum albumin
(B) β-hydroxybutyrate (BHB)
(C) Lactate dehydrogenase (LDH)

NODIA

2012

185. In an SDS-PAGE gel, what determines the pore size of the resolving gel?
(A) The concentration of SDS added to the buffer
(B) The total percentage of acrylamide and the ratio of bis-acrylamide cross-linker
(C) The voltage applied during the run
(D) The amount of ammonium persulfate used

2007

186. Which 2D gel electrophoresis artifact is known as "horizontal streaking"?
(A) Protein degradation during the run
(B) Incomplete solubilization or poor focusing during the first-dimension IEF
(C) Overloading the gel with too much sample
(D) Using old SDS running buffer

2023

187. Given below are statements regarding liquid scintillation counting:
I. Quenching is a phenomenon that reduces the overall counting efficiency.
II. Color quenching absorbs the emitted light photons before they hit the photomultiplier.
III. Chemical quenching absorbs the radioactive energy before it can excite the fluor.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I and II
(C) I and III
(D) II and III

2009

188. Order the sequence of events during a typical Northern Blot procedure.
I. RNA extraction and quantification
II. Electrophoresis through a denaturing agarose gel
III. Capillary transfer to a nylon membrane
IV. UV cross-linking of RNA to the membrane
V. Hybridization with a labeled probe
(A) I, II, III, IV, V
(B) II, I, III, IV, V
(C) I, III, II, IV, V
(D) I, II, IV, III, V

2007

189. The purity of a DNA sample is evaluated using UV spectrophotometry. An $\frac{A_{260}}{A_{280}}$ ratio of 1.8 indicates:
(A) Pure RNA
(B) Pure DNA
(C) Protein contamination
(D) Phenol contamination

2006

190. Match the items in List I with those in List II.
List I: (PCR Variant)
P. qPCR
Q. RT-PCR
R. Inverse PCR
S. Asymmetric PCR
List II: (Component or Feature)
1. Generates primarily single-stranded DNA by using unequal primer concentrations
2. Uses fluorescent dyes or probes for real-time quantification
3. Requires reverse transcriptase
4. Amplifies unknown sequences flanking a known core sequence
(A) P-II, Q-III, R-IV, S-I
(B) P-III, Q-II, R-I, S-IV
(C) P-II, Q-IV, R-III, S-I
(D) P-I, Q-III, R-II, S-IV

2007

191. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Restriction enzymes like BamHI and EcoRI create "sticky ends" when they cleave DNA.
Reason (R): Sticky ends consist of short, single-stranded overhangs that can easily hydrogen bond with complementary overhangs produced by the same enzyme.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

192. Which technique utilizes fluorescently labeled primers and capillary electrophoresis to determine the exact length of short tandem repeats (STRs)?
(A) Modern microsatellite DNA profiling
(B) RFLP analysis
(C) Southern blotting
(D) Northern blotting

2016

193. In molecular cloning, what is the primary purpose of adding IPTG and X-gal to the agar plates when using a pUC19 vector?

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2023

159. Given below are statements regarding Gel Filtration:

I. The exclusion limit defines the smallest molecule that cannot enter the pores.

II. Molecules smaller than the pores enter the beads and are delayed.

III. It can be used to desalt a protein solution.

Which of the above statement(s) is/are correct?

(A) II and III

(B) I and II

(C) I and III

(D) I, II and III

2007

160. Agarose is a linear polysaccharide extracted primarily from:

(A) Mammalian connective tissue

(B) Fungal cell walls

(C) Marine red algae (seaweed)

(D) Terrestrial plant roots

2021

161. Order the sequence of events for performing 2D Gel Electrophoresis.

I. Rehydration of the IPG (Immobilized pH Gradient) strip with the sample

II. Isoelectric focusing (First dimension)

III. Equilibration of the strip in SDS-containing buffer

IV. Separation on an SDS-PAGE gel (Second dimension)

V. Staining of the gel to visualize spots

(A) I, II, III, IV, V

(B) II, I, III, IV, V

(C) I, III, II, IV, V

(D) II, III, I, IV, V

2007

162. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.

Assertion (A): Geiger-Müller counters cannot determine the specific energy or type of radiation entering the tube.

Reason (R): Every radiation event that enters the GM tube triggers a complete avalanche discharge of constant amplitude, regardless of the initial particle's energy.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

2003

163. In the silica-based spin column method for DNA extraction, DNA binds to the silica membrane in the presence of:

(A) High concentrations of chaotropic salts

(B) Low concentrations of salt and high pH

(C) Pure distilled water

(D) Ethidium bromide

2006

164. What happens to the UV absorbance of double-stranded DNA when it is completely denatured into single strands?

(A) It decreases by 50%

(B) It remains unchanged

(C) It increases by approximately 30-40% (Hyperchromic effect)

(D) It shifts from 260 nm to 280 nm

2023

165. Which of the following is an absolute requirement for the extension phase of a PCR reaction?

(A) DNA template, primers, dNTPs, Taq, and Mg^{2+}.

(B) RNA template, RNA polymerase, rNTPs, and Mn^{2+}.

(C) Specific single primer and reverse transcriptase.

(D) Specific restriction enzymes to cut the template.

2025

166. Match the items in List I with those in List II.

List I: (Genetic Marker Type)

P. RFLP

Q. SNP

R. VNTR

S. STR

List II: (Defining Mechanism)

1. Presence or absence of restriction sites
2. Single base-pair variations in the genome
3. Long repetitive sequence blocks (minisatellites)
4. Short repetitive sequence blocks (microsatellites)

(A) P-I, Q-II, R-III, S-IV

(B) P-II, Q-I, R-IV, S-III

(C) P-III, Q-IV, R-I, S-II

(D) P-I, Q-II, R-IV, S-III

NODIA

2015

167. Which phenomenon provides the biological basis for using microsatellites in parentage testing?

mercaptoethanol
(C) Sodium chloride
(D) Water

2012

232. Cation-exchange resins contain which functional groups?
(A) Negatively charged groups (e.g., CM)
(B) Positively charged groups (e.g., DEAE)
(C) Hydrophobic carbon chains
(D) Affinity ligands

2023

233. Which type of GC column is characterized by a very small internal diameter (0.1–0.5 mm) and higher resolution compared to packed columns?
(A) Preparative column
(B) Wall-coated open tubular (WCOT) capillary column
(C) Adsorption column
(D) Guard column

2012

234. In affinity chromatography, the biospecific ligand is attached to a:
(A) Mobile phase solvent
(B) Photodetector
(C) Fraction collector
(D) Solid support matrix

2024

235. Acrylamide gels are polymerized using:
(A) APS and TEMED
(B) SDS and DTT
(C) Tris and Glycine
(D) EDTA and Borate

2013

236. The pI of a protein is the pH where it has:
(A) Maximum positive charge
(B) Maximum negative charge
(C) Zero net charge
(D) Maximum solubility

2016

237. Geiger-Müller counters operate in the:
(A) Geiger-Müller region
(B) Recombination region
(C) Ionization chamber region
(D) Proportional region

2016

238. RNase A is typically boiled before use to:
(A) Inactivate it completely
(B) Destroy any contaminating DNase activity
(C) Enhance its specific activity
(D) Solubilize the enzyme

2014

239. One unit of $A_{\{260\}}$ absorbance roughly equals what concentration of single-stranded RNA?
(A) 33 µg/mL
(B) 40 µg/mL
(C) 50 µg/mL
(D) 100 µg/mL

2017

240. The annealing temperature in PCR is typically set:
(A) 5°C above the primer T_m
(B) 3-5°C below the primer T_m
(C) At exactly 72°C
(D) At exactly 94°C

2008

241. Restriction enzymes naturally protect bacteria from:
(A) Antibiotics
(B) Viral (bacteriophage) infections
(C) Heat shock
(D) Heavy metals

2007

242. Capillary electrophoresis separates STRs with a resolution of:
(A) 100 base pairs
(B) 50 base pairs
(C) 1 base pair
(D) 1000 base pairs

2017

243. Nylon membranes are preferred over nitrocellulose for Southern blotting because they:
(A) Bind DNA covalently and are physically stronger
(B) Are more fragile
(C) Do not require baking or UV cross-linking
(D) Reject RNA binding

2019

244. Cosmids combine features of plasmids and:
(A) Lambda phages
(B) YACs
(C) BACs
(D) Retroviruses

2002

245. In competitive ELISA, maximum signal is obtained when the sample contains:
(A) Extremely high antigen concentration
(B) Zero target antigen
(C) Only secondary antibodies
(D) Denatured proteins

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(D) III, II, I, IV

2005

176. Which condition represents an exception to the Beer-Lambert law at high analyte concentrations?
(A) The path length becomes variable.
(B) Electrostatic interactions between analyte molecules alter their molar absorptivity.
(C) The solvent completely evaporates.
(D) The detector becomes more sensitive.

2014

177. In flame photometry, what is the purpose of adding an internal standard, such as Lithium, when analyzing for Sodium or Potassium?
(A) To increase the flame temperature
(B) To correct for variations in flame stability, sample viscosity, and nebulization rate
(C) To chemically reduce the analytes
(D) To precipitate interfering anions

2015

178. Given below are statements regarding isopycnic density gradient centrifugation:
I. Particles separate strictly according to their buoyant density.
II. Cesium chloride (CsCl) is commonly used to separate DNA based on GC content.
III. The centrifugation time must be perfectly timed to prevent particles from pelleting.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2006

179. Which reagent is commonly used to permeabilize eukaryotic cell membranes while keeping the nuclear envelope largely intact?
(A) Triton X-100 or Nonidet P-40
(B) 1% SDS
(C) Sodium hydroxide
(D) Phenol

2023

180. Match the items in List I with those in List II.
List I: (Mechanism)
P. Simple Dialysis
Q. Electrodialysis
R. Ultrafiltration
S. Diafiltration
List II: (Driving Force)
1. Hydrostatic pressure gradient
2. Concentration gradient
3. Electrical potential gradient
4. Continuous buffer exchange under pressure
(A) P-II, Q-III, R-I, S-IV
(B) P-I, Q-II, R-III, S-IV
(C) P-III, Q-I, R-IV, S-II
(D) P-II, Q-IV, R-I, S-III

2002

181. Why must the Biuret assay strictly require an alkaline environment?
(A) To facilitate the formation of the complex between Cu^{2+} and the peptide bonds
(B) To dissolve the protein completely
(C) To prevent the precipitation of copper sulfate
(D) To break all disulfide bonds

2023

182. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): In ion-exchange chromatography, the matrix must be thoroughly equilibrated with the starting buffer before loading the sample.
Reason (R): Equilibration ensures that the matrix functional groups are fully charged and complexed with the appropriate counter-ions for optimal protein binding.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022

183. In gas-liquid chromatography (GLC), the stationary phase is:
(A) A high-boiling liquid immobilized on a solid inert support
(B) A volatile liquid dissolved in the carrier gas
(C) A solid adsorbent material packed in a column
(D) A porous polymer membrane

2021

184. Which ligand would be most appropriate in affinity chromatography for purifying a population of mRNA molecules from total cellular RNA?
(A) Heparin sepharose
(B) Protein A agarose
(C) Concanavalin A
(D) Oligo(dT) cellulose

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2001

202. Which fuel-oxidant mixture produces the hottest flame in flame photometry?
(A) Nitrous oxide-Acetylene
(B) Air-Methane
(C) Air-Acetylene
(D) Oxygen-Hydrogen

2011

203. The sedimentation coefficient (Svedberg unit, S) is defined as:
(A) Sedimentation velocity per unit of centrifugal field
(B) Rotor speed per minute
(C) Density of the particle divided by density of the medium
(D) The time taken to reach the bottom of the tube

2010

204. Which method uses high-pressure gas decompression to gently disrupt cells?
(A) Sonication
(B) French press
(C) Nitrogen cavitation
(D) Bead beating

2019

205. Dialysis tubing is typically made from:
(A) Regenerated cellulose
(B) Polyacrylamide
(C) Nylon
(D) Nitrocellulose

2008

206. The Bradford assay depends on the shift in absorbance of Coomassie dye to which wavelength?
(A) 280 nm
(B) 540 nm
(C) 595 nm
(D) 750 nm

2022

207. In normal-phase chromatography, the stationary phase is:
(A) Non-polar
(B) Polar
(C) Highly hydrophobic
(D) A volatile gas

2007

208. Which GC detector is highly sensitive to halogen-containing compounds like pesticides?
(A) FID
(B) ECD
(C) TCD
(D) FPD

2002

209. Gel filtration separates molecules based on:
(A) Molecular size and shape
(B) Net charge
(C) Hydrophobicity
(D) Specific binding affinity

2023

210. In SDS-PAGE, proteins have a uniform:
(A) Mass
(B) Charge-to-mass ratio
(C) Shape
(D) Amino acid sequence

NODIA

2025

211. Isoelectric focusing relies on a pH gradient created by:
(A) SDS
(B) TEMED
(C) Bromophenol blue
(D) Ampholytes

2012

212. Scintillation cocktails contain fluors that emit:
(A) Visible light photons
(B) Alpha particles
(C) Beta particles
(D) X-rays

2017

213. Chloroform is used in DNA extraction primarily to:
(A) Promote phase separation and remove lipids
(B) Precipitate DNA
(C) Degrade RNA
(D) Inhibit DNase

2023

214. Pure RNA has an $\frac{A_{260}}{A_{280}}$ ratio of approximately:
(A) 2.0
(B) 1.5
(C) 1.8
(D) 2.5

2001

215. The optimum extension temperature for Taq polymerase is:
(A) 55°C
(B) 65°C
(C) 72°C
(D) 95°C

2008

216. RFLP fundamentally detects:
(A) Sequence length variations between

(A) To select for bacteria that have taken up the payload (antibiotic resistance)
(B) To induce blue/white screening for identifying recombinant colonies
(C) To increase the copy number of the plasmid
(D) To lyse the bacterial cells for DNA extraction

2010

194. In competitive ELISA for detecting a target antigen, a stronger color development at the end of the assay indicates:
(A) A higher concentration of the target antigen in the patient sample
(B) A lower concentration of the target antigen in the patient sample
(C) That the enzyme has denatured
(D) That the primary antibody was omitted

2017

195. Given below are statements regarding microarrays:
I. They can be used to compare gene expression profiles between healthy and diseased tissues.
II. In a two-color microarray, cDNA from two different samples are labeled with different fluorophores (e.g., Cy3 and Cy5).
III. The ratio of fluorescence intensities at each spot indicates the relative gene expression level.
IV. Microarrays are primarily used to sequence novel, unknown genomes.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) II, III and IV
(C) I, III and IV
(D) I, II and IV

2013

196. Which analytical technique involves ionizing chemical species and sorting the ions based on their mass-to-charge ratio ($\frac{m}{z}$)?
(A) Nuclear Magnetic Resonance (NMR)
(B) Mass Spectrometry
(C) X-ray Crystallography
(D) Isoelectric Focusing

2021

197. Order the basic steps of a proteomics workflow using LC-MS/MS.
I. Protein extraction and purification
II. Tryptic digestion into peptides
III. Liquid chromatography separation of peptides
IV. Tandem mass spectrometry and database searching
(A) I, II, III, IV
(B) II, I, III, IV
(C) I, III, II, IV
(D) III, II, I, IV

2002

198. Which application of nanotechnology aims to improve the bioavailability of poorly water-soluble veterinary drugs?
(A) Nanoencapsulation in solid lipid nanoparticles
(B) Development of atomic force microscopes
(C) Use of carbon nanotubes for tissue scaffolding
(D) Use of quantum dots for cell labeling

2013

199. A significant increase in serum Gamma-Glutamyl Transferase (GGT) in a cow is a highly specific indicator of:
(A) Skeletal muscle myopathy
(B) Biliary tract disease (cholestasis)
(C) Renal failure
(D) Rumen acidosis

2010

200. Match the items in List I with those in List II.
List I: (Diagnostic Marker)
P. Blood Urea Nitrogen (BUN)
Q. Creatinine
R. Glucose
S. Ketone bodies
List II: (Physiological Significance)
1. Primary energy substrate tightly regulated by insulin and glucagon
2. Breakdown product of muscle creatine phosphate; indicates glomerular filtration
3. Byproduct of hepatic protein/ammonia metabolism; indicates renal function and hydration status
4. Products of incomplete fat metabolism during states of negative energy balance
(A) P-III, Q-II, R-I, S-IV
(B) P-II, Q-III, R-I, S-IV
(C) P-III, Q-I, R-II, S-IV
(D) P-I, Q-II, R-III, S-IV

2017

201. The unit "Molar extinction coefficient" is expressed in:
(A) $Lmol^{-1}cm^{-1}$
(B) $molL^{-1}cm^{-1}$
(C) $gL^{-1}cm^{-1}$
(D) $Lg^{-1}cm^{-1}$

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(D) Blood Urea Nitrogen (BUN)

2001

150. Order the sequence of events in a standard indirect competitive RIA for measuring hormone levels.
I. Addition of the patient sample (unlabeled hormone)
II. Addition of a fixed amount of specific antibody
III. Addition of a known amount of radiolabeled hormone
IV. Separation of bound from free hormone and counting
(A) I, III, II, IV
(B) II, I, III, IV
(C) III, I, II, IV
(D) I, II, III, IV

2016

151. Which law describes the exponential decrease of light intensity as it passes through an absorbing medium?
(A) Beer-Lambert Law
(B) Faraday's Law
(C) Fick's Law
(D) Raoult's Law

2024

152. In Atomic Absorption Spectroscopy (AAS), the flame serves specifically to:
(A) Ionize the sample completely into plasma
(B) Excite the atoms to emit specific wavelengths
(C) Atomize the sample into ground-state free atoms
(D) Filter the light from the hollow cathode lamp

2003

153. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Ultracentrifuges operate in a high vacuum chamber.
Reason (R): The vacuum prevents air friction from heating the rotor at speeds that can exceed 100,000 RPM.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

154. Which subcellular fractionation marker enzyme is classically used to verify the purity of isolated lysosomes?
(A) Cytochrome c oxidase
(B) Acid phosphatase
(C) Lactate dehydrogenase
(D) Glucose-6-phosphatase

2005

155. During ammonium sulfate precipitation of proteins, what structural change initiates the "salting out" effect?
(A) Cleavage of peptide bonds
(B) Masking of hydrophobic patches
(C) Exposure of hydrophobic regions as water molecules are sequestered by the salt
(D) Denaturation of the secondary α-helices

2013

156. Match the items in List I with those in List II.
List I: (Protein Assay Characteristic)
P. Relies on Coomassie G-250
Q. Utilizes Folin-Ciocalteu reagent
R. Relies on BCA and Copper
S. Read at 280 nm
List II: (Assay Name)
1. Bradford assay
2. Lowry assay
3. BCA assay
4. UV Spectrophotometry
(A) P-I, Q-II, R-III, S-IV
(B) P-II, Q-I, R-IV, S-III
(C) P-III, Q-IV, R-I, S-II
(D) P-IV, Q-III, R-II, S-I

2025

157. Which component is the stationary phase in standard normal-phase thin-layer chromatography (TLC)?
(A) Hexane
(B) Silica gel
(C) Water
(D) Acetonitrile

2017

158. In reverse-phase HPLC, if a mixture of a highly polar compound and a highly non-polar compound is injected, which will elute first?
(A) The highly non-polar compound
(B) The highly polar compound
(C) They will elute simultaneously
(D) Neither will elute without changing the temperature

NODIA

restriction sites
(B) Total genomic GC content
(C) Protein molecular weights
(D) RNA secondary structures

2003

217. Microsatellites are also known as:
(A) VNTRs
(B) STRs
(C) SNPs
(D) LINEs

2006

218. The transfer of RNA to a membrane is called:
(A) Southern blotting
(B) Northern blotting
(C) Western blotting
(D) Eastern blotting

2016

219. A polylinker in a vector is a region containing:
(A) Multiple origins of replication
(B) Multiple unique restriction enzyme recognition sites
(C) Multiple promoter sequences
(D) Multiple antibiotic resistance genes

2021

220. The primary advantage of a sandwich ELISA is high:
(A) Speed
(B) Specificity and sensitivity
(C) Requirement for sample purification
(D) Use of radioactive isotopes

2001

221. MALDI-TOF separates ions based on their:
(A) Boiling point
(B) Time to reach the detector in a flight tube
(C) Affinity for a magnetic field
(D) Light absorption

2023

222. Gold nanoparticles exhibit unique optical properties due to:
(A) Radioactivity
(B) Phosphorescence
(C) Localized Surface Plasmon Resonance
(D) Tyndall effect

2004

223. AST is found in high concentrations in both liver and:
(A) Skeletal muscle
(B) Bone
(C) Pancreas
(D) Salivary glands

2024

224. Normal blood glucose levels are primarily maintained by:
(A) Insulin and glucagon
(B) Thyroid hormones
(C) Parathyroid hormone
(D) Aldosterone

2003

225. A primary indicator of hypocalcemia is low levels of:
(A) Serum glucose
(B) Serum ionized calcium
(C) Serum potassium
(D) Serum iron

2013

226. In fluorimetry, the emission wavelength is always:
(A) Shorter than the excitation wavelength
(B) Longer than the excitation wavelength
(C) Equal to the excitation wavelength
(D) Unrelated to the excitation wavelength

2011

227. Hollow cathode lamps are specific because the cathode is made of:
(A) Tungsten
(B) The same element being analyzed
(C) Quartz
(D) Platinum

2015

228. Ultracentrifuge rotors are typically made of:
(A) Titanium or aluminum alloys
(B) Glass
(C) Copper
(D) Stainless steel

2017

229. Dounce homogenizers disrupt cells via:
(A) High frequency sound
(B) Liquid shear forces
(C) Osmotic pressure
(D) Enzymatic degradation

2010

230. Salting out proteins at high salt concentrations relies on:
(A) Decreased hydrophobic interactions
(B) Increased hydrophobic interactions
(C) Cleavage of disulfide bonds
(D) Denaturation of the protein core

2001

231. The Lowry assay is sensitive to interference from:
(A) EDTA only
(B) Reducing agents like DTT and

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(A) Mendelian co-dominant inheritance of repeat alleles
(B) Somatic hypermutation in the immune system
(C) Epigenetic silencing of tandem repeats
(D) Horizontal gene transfer between individuals

2023

168. Given below are statements regarding probe hybridization:
I. DNA-DNA hybrids are more stable than RNA-RNA hybrids.
II. Formamide is often used in hybridization buffers to lower the melting temperature (T_m) of the probe-target duplex.
III. High GC content in the probe requires higher temperatures or lower formamide concentrations for specific hybridization.
Which of the above statement(s) is/are correct?
(A) II and III
(B) I and II
(C) I and III
(D) I, II and III

2018

169. What specific structural feature differentiates a Yeast Artificial Chromosome (YAC) from a standard bacterial plasmid?
(A) YACs contain an origin of replication.
(B) YACs contain telomeric and centromeric sequences.
(C) YACs have selectable marker genes.
(D) YACs consist of single-stranded DNA.

2010

170. In an indirect ELISA detecting specific viral antibodies in serum, a false positive could most likely result from:
(A) Insufficient washing after adding the primary antibody
(B) Forgetting to add the enzyme substrate
(C) Using a secondary antibody that does not bind to the primary antibody
(D) Using a highly specific monoclonal capturing antibody

2016

171. Which mass spectrometry technique is most commonly paired with liquid chromatography for complex proteome sequencing via tandem MS (MS/MS)?
(A) Electrospray Ionization (ESI)
(B) MALDI
(C) Surface-Enhanced Laser Desorption/ Ionization (SELDI)
(D) Inductively Coupled Plasma (ICP)

2021

172. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Nanoparticles can cross the blood-brain barrier (BBB) more effectively than many traditional drugs.
Reason (R): Their sub-micron size and surface functionalization allow them to exploit transcytosis pathways in brain endothelial cells.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2007

173. Elevation of Aspartate Aminotransferase (AST) is seen in muscle damage and liver damage. Which other enzyme should be evaluated alongside AST to determine if the source is specifically skeletal muscle?
(A) ALT
(B) Creatine Kinase (CK)
(C) Amylase
(D) Lipase

2007

174. Which biochemical test result is a hallmark of post-renal azotemia (e.g., resulting from a blocked urethra)?
(A) Elevated BUN and normal Creatinine
(B) Disproportionately high elevation of both BUN and Creatinine with hyperkalemia
(C) Low BUN and high Creatinine
(D) Normal BUN and normal Creatinine with severe proteinuria

2010

175. Order the diagnostic testing sequence for suspected hyperthyroidism in an older cat.
I. Observation of clinical signs (weight loss, polyphagia)
II. Measurement of total serum T_4
III. Measurement of free T_4 (by equilibrium dialysis) if total T_4 is borderline
IV. Initiation of anti-thyroid therapy based on confirmed results
(A) I, II, III, IV
(B) II, I, III, IV
(C) I, III, II, IV

NODIA

2016

246. Two-color DNA microarrays measure:
(A) Relative transcript abundance between two samples
(B) Absolute gene copy number
(C) Protein translation rates
(D) Ribosomal assembly speed

2012

247. Liposomes are highly effective drug carriers because they are:
(A) Highly radioactive
(B) Amphiphilic and biodegradable
(C) Rigid and impermeable
(D) Composed of heavy metals

2006

248. Elevations in serum Alkaline Phosphatase (ALP) in cats are:
(A) Always clinically insignificant
(B) Common due to long enzyme half-life
(C) Highly significant due to the very short enzyme half-life in cats
(D) Only associated with bone growth

2006

249. Which of the following is NOT a ketone body?
(A) Acetyl-CoA
(B) Acetoacetate
(C) β-hydroxybutyrate
(D) Acetone

2008

250. Diagnosis of hyperadrenocorticism (Cushing's disease) often involves measuring:
(A) Insulin levels
(B) Cortisol levels before and after dexamethasone suppression
(C) T_4 and TSH
(D) Parathyroid hormone

2009

251. A chromophore is the part of a molecule that:
(A) Absorbs UV or visible light
(B) Contributes to mass
(C) Emits radiation
(D) Causes precipitation

2010

252. Spectral interferences in AAS are best minimized using:
(A) Zeeman background correction
(B) A hotter flame
(C) A different solvent
(D) A glass cuvette

2005

253. Swinging-bucket rotors are preferred for density gradient centrifugation because:
(A) The gradient reorients smoothly parallel to the centrifugal force
(B) They spin faster than fixed-angle rotors
(C) They hold larger volumes
(D) They generate less heat

2011

254. Mild non-ionic detergents are used for cell lysis when the goal is to:
(A) Denature all proteins
(B) Preserve protein-protein interactions and enzymatic activity
(C) Extract DNA exclusively
(D) Destroy the cell wall of tough fungi

2022

255. Ammonium sulfate is the most common salt for protein precipitation because of its:
(A) High solubility and favorable Hofmeister series ranking
(B) Low solubility in water
(C) Ability to irreversibly denature proteins
(D) Low cost alone

2009

256. Which amino acid does NOT significantly absorb UV light at 280 nm?
(A) Tryptophan
(B) Tyrosine
(C) Phenylalanine
(D) Glycine

2015

257. Retention time in HPLC is the time elapsed between:
(A) Sample injection and maximum peak detection
(B) Pump startup and first peak detection
(C) First and last peak detection
(D) Turning on the detector and injection

2016

258. Splitless injection in GC is used primarily for:
(A) Trace analysis of very dilute samples
(B) Concentrated samples
(C) Gaseous samples only
(D) Solid samples

2017

259. A protein of 150 kDa and a protein of 50 kDa are separated on a Sephadex G-100 column (exclusion limit 100 kDa). Which elutes first?
(A) The 150 kDa protein
(B) The 50 kDa protein

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ANSWERS

1. (A) Absorbance is directly proportional to concentration and path length.
The Beer-Lambert law defines the relationship between the absorption of light and the properties of the material through which the light travels. It states that absorbance is directly proportional to both the concentration of the absorbing species and the path length of the sample. This principle allows for the quantification of solutes by measuring light attenuation in liquid solutions.

2. (C) Hollow cathode lamp
Atomic Absorption Spectroscopy utilizes a hollow cathode lamp to produce narrow, element-specific emission lines. This lamp contains a cathode made of the target element, which, when excited, emits light at wavelengths precisely absorbed by ground-state atoms in the flame. This specificity ensures high sensitivity and minimal spectral interference for detecting trace metal concentrations in various biological samples.

3. (D) A is false but R is true.
Density gradient centrifugation separates particles based on their buoyant density relative to the surrounding medium, not solely on size or shape. Particles migrate until they reach a point where their density equals that of the gradient. While the medium's increasing density from top to bottom is true, the assertion that size is the only factor is incorrect.

4. (D) French press homogenization
French press homogenization is a mechanical cell disruption technique that involves forcing a cell suspension through a very narrow valve under extremely high pressure. As the cells exit the valve, the rapid drop in pressure causes them to expand and burst. This method is particularly effective for breaking tough cell walls in bacteria, yeasts, and plant tissues efficiently.

5. (A) P-II, Q-IV, R-I, S-III
Salting out involves decreased protein solubility at high salt concentrations due to competition for water molecules. Dialysis removes small molecules through a semi-permeable membrane via passive diffusion. Ultrafiltration separates molecules based on molecular weight cutoff under pressure. Salting in increases protein solubility at low salt concentrations through electrostatic interactions. These mechanisms are fundamental for protein purification and concentration.

NODIA

6. (C) The BCA assay is highly susceptible to interference from common detergents like SDS.
The bicinchoninic acid assay is renowned for its high tolerance to various detergents, including sodium dodecyl sulfate, making it a preferred choice for samples containing these agents. In contrast, other methods like the Lowry assay are easily disrupted by such detergents. This compatibility allows for accurate protein quantification in membrane protein studies where detergents are essential for solubilization.

7. (B) I and III
Partition chromatography separates chemical substances based on their relative solubility differences between two immiscible liquid phases. Cation-exchange chromatography employs a matrix with negative charges to capture positively charged molecules from a mixture. Normal-phase adsorption chromatography is characterized by the use of a polar stationary phase and a non-polar mobile phase, meaning the description of non-polar stationary phases is inaccurate.

8. (A) Vapor pressure and affinity for the stationary phase.
In gas chromatography, the retention time of a volatile compound is primarily determined by its vapor pressure and its specific affinity for the stationary phase. Higher vapor pressure and lower affinity result in faster movement through the column. These factors depend on the chemical structure of the analyte and the temperature settings, which facilitate the separation process.

9. (B) Largest molecules elute first, followed by intermediate, then smallest molecules.
Gel filtration chromatography separates molecules based on their size relative to the pores of a stationary phase. Larger molecules are excluded from the pores and travel quickly through the void volume, eluting first. Smaller molecules enter the pores and are delayed by a longer path,

2024

273. An increase in AST without a corresponding increase in ALT strongly suggests:
(A) Skeletal or cardiac muscle injury
(B) Severe acute hepatic necrosis
(C) Pancreatitis
(D) Biliary obstruction

2014

274. In a dehydrated animal, BUN increases while serum creatinine often remains relatively normal initially. This is called:
(A) Pre-renal azotemia
(B) Primary renal failure
(C) Post-renal azotemia
(D) Glomerulonephritis

2023

275. Measurement of serum fructosamine is preferred over single blood glucose readings for monitoring diabetes because it reflects:
(A) Average blood glucose concentrations over the previous 1-3 weeks
(B) Immediate blood sugar levels
(C) The exact peak of insulin activity
(D) Only fasting glucose levels

2002

276. The linear range of the Beer-Lambert law typically fails at absorbances above:
(A) 0.1
(B) 0.5
(C) 1.0 to 1.5
(D) 5.0

2016

277. Flame emission photometry is most suitable for detecting:
(A) Alkali and alkaline earth metals (Na, K, Ca, Li)
(B) Heavy transition metals
(C) Noble gases
(D) Halogens

2009

278. Density gradient centrifugation uses a medium like sucrose to prevent:
(A) Convection currents and stabilize the sedimenting bands
(B) The rotor from over-speeding
(C) Protein precipitation
(D) DNA denaturation

2013

279. Which homogenizer type forces tissue between a rotating pestle and a glass tube?
(A) Potter-Elvehjem
(B) Waring blender
(C) French press
(D) Sonicator

2018

280. Ultrafiltration membranes separate molecules based primarily on:
(A) Molecular weight and physical size
(B) Isoelectric point
(C) Hydrophobicity
(D) Affinity for cellulose

2003

281. The colorimetric product of the BCA assay is read at:
(A) 260 nm
(B) 280 nm
(C) 562 nm
(D) 595 nm

2006

282. In HPLC, specific column guard columns are used to:
(A) Protect the analytical column from particulate matter and irreversibly bound compounds
(B) Increase the mobile phase flow rate
(C) Act as the primary detector
(D) Cool the mobile phase

NODIA

2013

283. Temperature programming in GC is analogous to what technique in HPLC?
(A) Gradient elution
(B) Isocratic elution
(C) Normal-phase separation
(D) Chiral separation

2010

284. Which spacer arm length is typically optimal in affinity chromatography to prevent steric hindrance?
(A) 4-10 atoms
(B) 1-2 atoms
(C) 50-100 atoms
(D) No spacer arm is ever used

2012

285. Silver staining is preferred over Coomassie blue when:
(A) Maximum sensitivity for trace amounts of protein is required
(B) Protein concentrations are very high
(C) Preparing gels for immediate Western blotting
(D) Quantifying proteins by UV absorbance

(C) They elute together in the void volume
(D) Neither elutes

2010

260. The stacking gel in SDS-PAGE has a:
(A) Lower acrylamide concentration and lower pH than the resolving gel
(B) Higher acrylamide concentration and lower pH than the resolving gel
(C) Higher acrylamide concentration and higher pH than the resolving gel
(D) Lower acrylamide concentration and higher pH than the resolving gel

2003

261. IEF is highly effective for separating protein variants that differ by a single:
(A) Amino acid substitution that changes the net charge
(B) Glycosylation that does not change charge
(C) Lipid attachment
(D) Disulfide bond reduction

2017

262. Autoradiography exposes X-ray film to detect:
(A) Radioactive isotopes within a sample
(B) Fluorescent tags
(C) Enzyme-linked color reactions
(D) Heavy metal stains

2022

263. During phenol-chloroform extraction, DNA partitions into the:
(A) Upper aqueous phase
(B) Lower organic phase
(C) Interphase
(D) It forms a precipitate immediately

2002

264. An $\frac{A_{260}}{A_{230}}$ ratio of 0.8 typically indicates contamination with:
(A) Salts or organic solvents
(B) Pure RNA
(C) Pure DNA
(D) Intact proteins

2002

265. Hot-start PCR utilizes modified Taq polymerase to prevent:
(A) Non-specific amplification at low temperatures during reaction setup
(B) Premature degradation of the template DNA
(C) Evaporation of the reaction mix
(D) Rapid utilization of dNTPs

2012

266. RFLP analysis has been largely superseded in forensics due to its requirement for:
(A) Large amounts of intact, high-molecular-weight DNA
(B) Very small amounts of highly degraded DNA
(C) Extremely specific primers
(D) Capillary sequencers

2007

267. STR loci are highly polymorphic due to:
(A) Replication slippage during DNA synthesis
(B) High rates of point mutations
(C) Transposon insertions
(D) Viral integrations

2016

268. A Southern blot probe must be:
(A) Complementary to the target sequence and labeled for detection
(B) A double-stranded DNA molecule that remains double-stranded
(C) A specific antibody against DNA
(D) An RNA polymerase

2023

269. BAC vectors are based on the:
(A) E. coli F-factor plasmid
(B) M13 phage genome
(C) Yeast centromere
(D) Retroviral LTRs

2004

270. Direct ELISA is generally less sensitive than indirect ELISA because:
(A) There is no signal amplification from secondary antibodies
(B) It requires a much larger sample volume
(C) The enzymes used are less active
(D) The incubation times are much shorter

2011

271. Microarrays analyze the transcriptome by measuring:
(A) Global mRNA expression levels
(B) Global protein translation
(C) The speed of RNA polymerase
(D) The size of genomic introns

2003

272. Quantum dots are advantageous over traditional organic fluorophores due to their:
(A) Resistance to photobleaching and broad excitation spectra
(B) High rate of photobleaching
(C) Short half-lives
(D) Rapid biodegradation

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2023

299. In veterinary diagnostics, the Free T_4 (fT_4) assay by equilibrium dialysis is superior to total T_4 measurement because:

(A) It measures only the biologically active unbound hormone, avoiding interference from binding proteins
(B) It is much cheaper
(C) It uses radioactive iodine
(D) It requires only a single drop of blood

2002

300. Given below are statements regarding clinical endocrinology:

I. TRH stimulation test is used to evaluate thyroid function.
II. An ACTH stimulation test is commonly used to diagnose Addison's disease.
III. TSH levels are invariably high in feline hyperthyroidism.

Which of the above statement(s) is/are correct?

(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

NODIA

****

by their molecular weight using standard SDS-polyacrylamide gel electrophoresis. This combination provides exceptional resolution for complex protein mixtures, allowing for the separation of hundreds or thousands of individual spots on a single gel for analysis.

37. (D) Solid-state scintillation detector (NaI crystal)
A solid-state scintillation detector, such as a thallium-activated sodium iodide crystal, is the most appropriate tool for monitoring high-energy gamma radiation. Gamma rays interact with the dense crystal lattice, producing light flashes that are then amplified by a photomultiplier tube. This detector offers high efficiency for gamma detection compared to gas-filled counters, which are better suited for lower energy or particulate radiation.

38. (C) To neutralize the pH and precipitate genomic DNA and proteins
Potassium acetate is used during alkaline lysis for plasmid DNA extraction to neutralize the high pH of the lysis buffer. This rapid neutralization causes the large, denatured genomic DNA and proteins to aggregate and precipitate as an insoluble complex. Small, circular plasmid DNA renatures quickly and remains in the supernatant, allowing for its selective recovery after centrifugation of the precipitated debris.

39. (B) A_260/A_230 ratio
The $\frac{A_{260}}{A_{230}}$ ratio is a critical metric for assessing the purity of nucleic acid samples regarding carryover from organic solvents, carbohydrates, or chaotropic salts like guanidine. These contaminants absorb light strongly at 230 nanometers. A low ratio, typically below 2.0, indicates the presence of these substances, which can inhibit downstream enzymatic reactions. Monitoring this ratio ensures the quality of samples for molecular biology experiments.

40. (B) I, III and IV
Reverse transcriptase PCR utilizes the enzyme reverse transcriptase to synthesize cDNA from an RNA template before standard amplification. This method is widely used to quantify viral RNA loads and study gene expression. Oligo(dT) primers are frequently employed to specifically target the poly(A) tail of eukaryotic messenger RNA. It does not amplify RNA directly, as a DNA intermediate is always required.

41. (B) Cleavage of DNA at non-canonical recognition sites under sub-optimal conditions
Star activity refers to the relaxation of restriction enzyme specificity, leading to DNA cleavage at non-canonical recognition sites. This behavior occurs under sub-optimal conditions such as high glycerol concentration, low ionic strength, or incorrect pH. Using enzymes with star activity can result in unexpected banding patterns, which complicates the interpretation of cloning and mapping experiments. Proper buffer conditions are essential to prevent this.

42. (A) II, IV, I, III
Performing a Southern blot begins with the digestion of genomic DNA using restriction enzymes. The resulting fragments are then separated by size through agarose gel electrophoresis. After separation, the DNA is transferred to a nylon or nitrocellulose membrane. Finally, the membrane is hybridized with a labeled specific probe to identify the target sequences, completing the detection of specific DNA fragments.

43. (B) Northern blotting analyzes RNA, while Southern blotting analyzes DNA.
Northern and Southern blotting are fundamental techniques for analyzing nucleic acids, differing primarily in their target molecules. Northern blotting is used to detect specific RNA sequences and assess gene expression levels. Southern blotting is designed for the detection and mapping of specific DNA sequences within a genome. Both techniques involve electrophoresis, membrane transfer, and hybridization with labeled probes to visualize the targets.

44. (C) Bacterial Artificial Chromosome (BAC)
Bacterial Artificial Chromosomes are specialized vectors designed to accommodate very large DNA inserts, typically ranging from one hundred to three hundred kilobases. Their high carrying capacity makes them ideal for constructing comprehensive genomic libraries and mapping complex genomes. Based on the F-plasmid of bacteria, they replicate at a low copy number, ensuring the stability of the large inserted genomic fragments during maintenance.

45. (B) Inversely proportional to the concentration of unlabeled antigen in the patient sample.
In a competitive radioimmunoassay, a fixed amount of radiolabeled antigen competes with

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resulting in later elution. This method allows for effective size-based fractionation and desalting.

10. (B) Agarose gel electrophoresis - Resolution of large DNA fragments
Agarose gel electrophoresis is the standard technique for resolving large DNA fragments due to its relatively large pore size. This matrix allows nucleic acids to migrate based on their size and charge under an electric field. While polyacrylamide gels provide higher resolution for smaller fragments, agarose is ideal for typical genomic DNA and plasmid analysis in molecular biology.

11. (A) Cathode - The positively charged electrode where low pH is maintained
In isoelectric focusing, the cathode is the negatively charged electrode where high pH conditions are typically found, whereas the anode is the positively charged electrode maintained at a low pH. The technique utilizes ampholytes to establish a stable pH gradient across the gel. Proteins migrate until they reach the specific pH where their net electrical charge becomes zero.

12. (A) Both A and R are true and R is the correct explanation of A.
Liquid scintillation counting is highly efficient for detecting low-energy beta emitters because the radioactive sample is dissolved directly into a solvent containing fluors. This intimate contact minimizes self-absorption of the weak beta particles, which would otherwise be absorbed by the sample or air. The energy from the particles is transferred to the fluor, which then emits light.

13. (D) To denature and partition proteins away.
Phenol is a powerful organic solvent used during genomic DNA extraction to denature proteins and facilitate their removal. When mixed with the cell lysate, proteins lose their native structure and accumulate at the interface between the aqueous and organic phases. This process effectively purifies the nucleic acids, which remain in the upper aqueous layer for subsequent recovery.

14. (C) The sample contains significant protein.
Pure RNA typically exhibits an $\frac{A_{260}}{A_{280}}$ ratio of approximately 2.0, while pure DNA shows a ratio of about 1.8. A ratio of 1.4 suggests significant protein contamination, as aromatic amino acids absorb strongly at 280 nm. This lower value indicates that the sample requires further purification steps to remove non-nucleic acid components before being used in sensitive downstream applications.

15. (B) I, III and IV
The polymerase chain reaction involves denaturation at high temperatures, primer annealing determined by melting temperature, and real-time monitoring in quantitative PCR. Taq polymerase is valued for its thermostability but actually lacks the high proofreading activity found in Pfu polymerase. These steps combined allow for the exponential amplification and precise quantification of target DNA sequences in various research and diagnostics.

NODIA

16. (D) Variations in length of specific DNA fragments
Restriction Fragment Length Polymorphism analysis relies on detecting variations in the length of DNA fragments produced by restriction enzyme digestion. These differences often result from mutations that create or destroy recognition sites or from variable numbers of tandem repeats between sites. The resulting unique banding patterns are visualized after electrophoresis and blotting, providing a basis for genetic identification and mapping.

17. (A) P-IV, Q-I, R-II, S-III
Microsatellites consist of short tandem repeats, whereas minisatellites are longer, highly polymorphic sequences. Variable number tandem repeats is a general term encompassing these repetitive loci used in genetic profiling. Restriction fragment length polymorphism relies on point mutations that alter specific enzyme recognition sites. These markers are essential tools for DNA fingerprinting, parentage testing, and genetic diversity studies in animals.

18. (C) Non-specific hybridization due to low stringency conditions
Unexpected bands on a Southern blot are frequently caused by non-specific hybridization, where the probe binds to sequences with partial homology. This often occurs under low stringency conditions, such as low temperature or high salt concentration. Increasing the stringency during the washing steps ensures that only perfectly matched probe-target hybrids remain, thereby improving the specificity and clarity of the results.

2011

286. 2D-PAGE resolution is limited for highly hydrophobic membrane proteins because they:
(A) Often precipitate during the isoelectric focusing step
(B) Migrate too fast
(C) Do not bind SDS
(D) Have no isoelectric point (pI)

2002

287. Which component converts the light flash from a scintillator into an amplified electrical pulse?
(A) Photomultiplier tube (PMT)
(B) Monochromator
(C) Amplifier diode
(D) Chopper

2010

288. To prevent DNA shearing during genomic DNA extraction, one must avoid:
(A) Vigorous vortexing
(B) Using cold buffers
(C) Adding Proteinase K
(D) Centrifugation

2008

289. Extracted RNA is highly susceptible to degradation because RNases:
(A) Are ubiquitous, highly stable enzymes that do not require metal cofactors
(B) Require metal cofactors that are always present
(C) Are activated by low temperatures
(D) Cannot be inhibited by any known chemicals

2021

290. Degenerate primers in PCR are used when:
(A) Amplifying highly conserved regions where the exact codon usage is unknown
(B) The exact target sequence is fully known
(C) Preventing any amplification
(D) Conducting Real-Time PCR on specific alleles

2010

291. Which sequence is a common recognition site for a Type II restriction endonuclease?
(A) A palindromic sequence like GAATTC
(B) A sequence of repeating adenines
(C) A totally random 10-base sequence
(D) Telomeric ends

2008

292. Multiplex STR analysis uses fluorescent primers to:
(A) Distinguish different loci that may have overlapping size ranges
(B) Increase the speed of the Taq polymerase
(C) Prevent primer dimers
(D) Degrade the template after PCR

2012

2023

293. Formamide decreases the melting temperature (T_m) of DNA hybrids by:
(A) Disrupting hydrogen bonds between base pairs
(B) Increasing salt concentration
(C) Cleaving the phosphodiester backbone
(D) Covalently modifying purines

2014

294. Phagemids are vectors that combine features of:
(A) Plasmids and filamentous phages like M13
(B) BACs and YACs
(C) Cosmids and Lambda phages
(D) E. coli and Yeast genomes

2005

295. In RIA, the standard curve is typically plotted as:
(A) Bound radioactivity versus known concentrations of unlabeled antigen
(B) Free radioactivity versus time
(C) Absorbance versus wavelength
(D) Fluorescence versus temperature

2019

296. In proteomics, a "bottom-up" approach refers to:
(A) Digesting proteins into peptides before mass spectrometry analysis
(B) Analyzing whole intact proteins
(C) Sequencing mRNA to infer protein sequence
(D) Starting from the least abundant proteins

2023

297. Superparamagnetic iron oxide nanoparticles (SPIONs) are heavily researched for use as contrast agents in which imaging modality?
(A) Magnetic Resonance Imaging (MRI)
(B) Ultrasound
(C) X-ray radiography
(D) Positron Emission Tomography (PET)

2008

298. Elevated levels of serum amylase and lipase in a dog presenting with acute abdominal pain and vomiting strongly point toward:
(A) Acute pancreatitis
(B) Acute hepatitis
(C) Chronic renal failure
(D) Hypothyroidism

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are used for elemental analysis, but absorption is generally more sensitive and specific.

28. (A) Both A and R are true and R is the correct explanation of A.
Differential pelleting is a common centrifugation technique used to separate sub-cellular organelles based on their distinct sedimentation coefficients. Larger and denser particles, such as nuclei and mitochondria, experience greater centrifugal force and sediment faster than smaller, less dense particles. By applying sequential steps of increasing centrifugal speed, different fractions of the cell homogenate can be effectively isolated for biochemical study.

29. (C) Ultrasonication
Ultrasonication relies on the generation of cavitation bubbles through high-frequency sound waves in a liquid medium. When these bubbles collapse rapidly, they create intense local pressure and shear forces that disrupt cell membranes and walls. This mechanical method is highly effective for breaking open bacterial and animal cells in small-scale laboratory settings, although it can generate heat requiring careful temperature control.

30. (C) Frequently changing the surrounding buffer solution
The speed of salt removal during protein dialysis is primarily driven by the concentration gradient across the semi-permeable membrane. Frequently changing the surrounding buffer solution maintains a steep gradient, thereby accelerating the outward diffusion of small ions. This practice ensures that the concentration of salt in the dialysate remains low, maximizing the efficiency of the purification process for the macromolecular sample.

31. (C) Biuret assay
The Biuret assay exhibits minimal protein-to-protein variation because it relies on the direct interaction of copper ions with peptide bonds in an alkaline environment. Unlike the Bradford or Lowry assays, which depend on specific amino acid side chains like tyrosine or arginine, the Biuret method quantifies the total number of peptide bonds present. This makes it a highly reliable, though less sensitive, technique.

NODIA

32. (B) I and III
Reverse-phase high-performance liquid chromatography utilizes a non-polar stationary phase and a polar mobile phase to separate compounds. Smaller particle sizes in the stationary phase enhance column resolution by increasing the surface area for interaction. Isocratic elution, however, maintains a constant mobile phase composition, whereas gradient elution involves changing the composition over time to improve the separation of complex mixtures.

33. (B) Helium
Helium is generally preferred as a carrier gas in gas chromatography due to its chemical inertness and safety. While hydrogen offers slightly higher efficiency and faster separation times, it poses a significant fire and explosion risk. Helium provides a good compromise between performance and laboratory safety, making it the most common choice for many analytical applications in research and clinical settings.

34. (B) High concentration of free ligand or pH alteration.
Specifically bound proteins in affinity chromatography are typically eluted by introducing a high concentration of free ligand or by altering the buffer pH. The free ligand competes with the bound protein for the matrix-attached sites, while pH changes disrupt the specific non-covalent interactions. These methods ensure that the target protein is released from the column in a purified and often active form.

35. (A) P-III, Q-I, R-II, S-IV
Sodium dodecyl sulfate imparts a uniform negative charge to proteins, while beta-mercaptoethanol reduces disulfide bonds to linearize them. TEMED serves as a catalyst to initiate the polymerization of acrylamide in gel preparation. Bromophenol blue is used as a tracking dye to monitor the progress of the electrophoretic run. These reagents are essential for successful and standardized protein separation during denaturing electrophoresis.

36. (B) The first dimension separates proteins based on molecular weight.
In two-dimensional gel electrophoresis, the first dimension separates proteins based on their isoelectric point using a pH gradient. The second dimension then separates the focused proteins

19. (A) Plasmid, Bacteriophage lambda, BAC, YAC
DNA vectors vary significantly in their capacity to carry foreign genetic inserts. Standard plasmids typically accommodate up to ten kilobases, while bacteriophage lambda vectors can hold up to twenty-five kilobases. Bacterial artificial chromosomes handle much larger inserts up to three hundred kilobases. Yeast artificial chromosomes offer the highest capacity, capable of carrying genomic fragments exceeding one thousand kilobases for complex studies.

20. (B) IV only
Competitive enzyme-linked immunosorbent assays involve competition between sample antigens and labeled antigens for antibody binding sites. Higher concentrations of the target antigen in the patient sample result in less labeled antigen binding to the plate. Consequently, the final colorimetric signal is inversely proportional to the antigen concentration. Therefore, a stronger signal actually indicates a lower concentration of the target analyte.

21. (B) Microarrays analyze transcription, while LC-MS profiles proteins.
DNA microarrays are powerful tools used to simultaneously monitor the transcription levels of thousands of genes by measuring mRNA abundance. In contrast, liquid chromatography coupled with mass spectrometry is a primary technique in proteomics for identifying and quantifying proteins in complex biological samples. Both methods provide comprehensive profiles of the molecular state, addressing different levels of biological information.

22. (B) II, I, III, IV
Utilizing nanoparticles for targeted drug delivery involves a logical sequence beginning with the encapsulation of the therapeutic agent. Next, the nanoparticle surface is functionalized with specific ligands to ensure targeting. After intravenous administration, these modified constructs circulate until they bind to specific receptors on the target cells. This systematic approach enhances drug efficacy while minimizing side effects to healthy tissues.

23. (D) Alanine aminotransferase (ALT)
Alanine aminotransferase is widely considered the most liver-specific indicator of hepatocellular damage in dogs and cats. While other enzymes like aspartate aminotransferase are present in the liver, they are also found in high concentrations in muscle tissue. Significant elevations in serum alanine aminotransferase activity typically reflect acute or chronic injury to hepatocytes, making it a critical diagnostic enzyme.

24. (A) Kidney
An elevation in both blood urea nitrogen and serum creatinine, a condition known as azotemia, most strongly indicates renal dysfunction. These metabolites are primarily excreted by the kidneys through glomerular filtration. When the kidneys fail to function adequately, these substances accumulate in the blood. This finding is central to diagnosing various stages of acute or chronic renal disease in animals.

25. (B) Measurement of low serum total T_4 and high TSH
Primary hypothyroidism in domestic animals is most accurately identified by measuring low serum total thyroxine levels in conjunction with high thyroid-stimulating hormone concentrations. The lack of negative feedback from low thyroxine levels causes the pituitary gland to increase thyroid-stimulating hormone production. This diagnostic combination helps distinguish primary thyroid gland failure from other non-thyroidal illnesses that may lower thyroxine levels.

26. (D) Stray light reaching the detector
Deviations from the Beer-Lambert law can occur due to instrumental factors like stray light reaching the detector. Stray light refers to radiation outside the selected wavelength band, which can lead to negative errors in absorbance readings, especially at high concentrations. Other causes include chemical interactions at high analyte concentrations and non-monochromatic light, which interfere with the linear relationship between absorbance and concentration.

27. (A) Flame photometry measures emission; AAS measures absorption.
Flame photometry and Atomic Absorption Spectroscopy differ fundamentally in their analytical approach. Flame photometry measures the intensity of light emitted by atoms that have been excited by the flame's heat. Atomic Absorption Spectroscopy measures the amount of light absorbed by ground-state atoms from an external light source. Both techniques

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unlabeled antigen from the patient sample for limited antibody binding sites. A higher concentration of unlabeled antigen results in fewer labeled antigens binding to the antibodies. Consequently, the radioactivity measured in the bound fraction is inversely proportional to the concentration of the antigen being measured in the patient's biological sample.

46. (A) Both A and R are true and R is the correct explanation of A.
MALDI-TOF mass spectrometry is a powerful diagnostic tool for identifying bacteria based on their unique protein fingerprints. The matrix-assisted laser desorption ionization process is a soft ionization technique that allows large biomolecules, such as proteins, to enter the gas phase without extensive fragmentation. This preservation of intact molecular ions enables the generation of highly specific mass spectra used for rapid microbial identification.

47. (C) Gold nanoparticles
Gold nanoparticles are commonly utilized in lateral flow assays to provide a distinct, visible read-out line. Their unique optical properties, resulting from localized surface plasmon resonance, produce a bright red color when concentrated at the test or control lines. These nanoparticles are easily conjugated to antibodies, allowing for the rapid and sensitive detection of various analytes, such as hormones or pathogens.

48. (B) Creatine kinase (CK)
Creatine kinase is the most specific indicator of skeletal muscle damage in horses and other domestic animals. This enzyme is found in high concentrations in muscle cells and is released into the bloodstream following injury or heavy exercise. Because it has a short half-life, elevated levels indicate recent or ongoing muscle damage, making it essential for diagnosing conditions like exertional rhabdomyolysis.

49. (B) Diabetic ketoacidosis
Elevated concentrations of ketone bodies, including beta-hydroxybutyrate and acetoacetate, are characteristically associated with diabetic ketoacidosis. This condition occurs when a lack of insulin prevents cells from utilizing glucose, leading to excessive fat breakdown and the subsequent production of ketones. This metabolic state causes systemic acidosis and is a serious medical emergency in veterinary patients, particularly in dogs and cats with diabetes.

50. (A) Progesterone
Progesterone is the primary immunoassay marker measured to confirm the occurrence of ovulation in domestic animals like cattle and dogs. After ovulation, the ruptured follicle transforms into the corpus luteum, which secretes high levels of progesterone. Monitoring the rise in serum progesterone concentrations allows veterinarians and breeders to verify that ovulation has occurred and to determine the optimal timing for breeding.

51. (B) Stokes shift
The Stokes shift describes the phenomenon where a fluorescent molecule absorbs light at one wavelength and emits it at a longer, lower-energy wavelength. This energy difference occurs because some energy is lost through vibrational relaxation before photon emission. The shift is essential for fluorescence microscopy and spectroscopy, as it allows for the effective separation of excitation light from the emitted fluorescent signal.

52. (C) Self-absorption interference
Self-absorption interference in flame photometry occurs when ground-state atoms in the cooler outer regions of the flame absorb the radiation emitted by excited atoms of the same element in the hotter core. This phenomenon reduces the total light reaching the detector and can lead to non-linear calibration curves at high analyte concentrations. It is a specific spectral interference common in elemental analysis.

53. (A) P-II, Q-IV, R-III, S-I
Revolutions per minute measures rotor speed, while relative centrifugal force expresses the force exerted in units of gravity. A nomogram is a graphical tool used to convert between these two parameters. The sedimentation coefficient defines a particle's sedimentation velocity relative to the applied acceleration. These parameters are fundamental for designing and interpreting centrifugation experiments in biochemical research and clinical diagnostics.

54. (C) Polyvinylpyrrolidone (PVP)
Polyvinylpyrrolidone is frequently added to homogenization buffers when extracting enzymes from plant tissues to inhibit polyphenolooxidases.

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insulin lowers blood glucose levels. These hormones are essential for maintaining homeostasis across various physiological systems. Understanding their specific regulatory functions is fundamental for diagnosing and managing endocrine disorders in veterinary clinical practice and research.

126. (A) An increase in absorption intensity at a constant wavelength
A hyperchromic shift in UV spectrophotometry refers to an increase in the absorption intensity of a substance at a constant wavelength. This phenomenon is famously observed when double-stranded DNA denatures into single strands, leading to a significant increase in absorbance at 260 nanometers. This shift is a valuable tool for monitoring DNA melting and evaluating the purity and structural state of nucleic acids.

127. (C) Nebulizer
The nebulizer is the component of a flame photometer responsible for breaking the liquid sample into a fine aerosol of droplets. This aerosol is then mixed with fuel and oxidant before entering the flame. Proper nebulization is essential for ensuring that the sample is efficiently atomized and excited, leading to stable and reproducible emission signals for elemental analysis in biological samples.

128. (B) The pelleting efficiency of the rotor
The clearing factor, or k-factor, of a centrifuge rotor serves as an index of its pelleting efficiency. A lower k-factor indicates a more efficient rotor that can pellet a specific particle in less time at a given speed. This value is mathematically related to the rotor's geometry and speed, allowing researchers to estimate and compare the time required for various sedimentation tasks.

129. (B) Isotonic sucrose or mannitol medium
When isolating active mitochondria from liver tissue, an isotonic sucrose or mannitol medium is essential to maintain organelle integrity. These solutes provide the necessary osmotic pressure to prevent the mitochondria from swelling or bursting. Maintaining a stable, cold, and isotonic environment ensures that the isolated mitochondria remain functionally active for subsequent biochemical assays, such as respiratory studies or enzyme measurements.

130. (A) II and III
Dialysis is a slow process driven by a concentration gradient, typically taking several hours or overnight to reach equilibrium. The semi-permeable membrane is designed to retain macromolecules while allowing small ions and molecules to pass through. Therefore, claiming that it completes within minutes or that the membrane allows passage of macromolecules while retaining small ions is incorrect and reflects a misunderstanding.

131. (B) Tyrosine and Tryptophan
In the Lowry protein assay, the reduction of the Folin-Ciocalteu reagent is primarily mediated by the aromatic amino acid residues tyrosine and tryptophan. These residues, along with the copper-catalyzed peptide bonds, contribute to the development of the characteristic blue color. Because the assay depends on these specific amino acids, it can exhibit some variation in sensitivity between different proteins with varying compositions.

132. (A) Both A and R are true and R is the correct explanation of A.
In ion-exchange chromatography, proteins bound to the stationary phase are typically eluted by gradually increasing the salt concentration of the mobile phase. The added salt ions compete with the charged proteins for the functional groups on the matrix. As the salt concentration rises, the proteins are displaced and elute from the column, allowing for their separation based on their individual charge densities.

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133. (B) Strong, irreversible interactions between the analyte and active sites on the column
Tailing of peaks in gas chromatography is most commonly caused by strong or irreversible interactions between the analyte molecules and active sites on the column wall or stationary phase. These interactions delay a portion of the analyte, leading to an asymmetric peak with a drawn-out trailing edge. This phenomenon reduces resolution and quantification accuracy, often requiring column deactivation or replacement to resolve.

134. (B) Nickel or Cobalt ions
Nickel or cobalt ions are typically immobilized on the matrix in metal affinity chromatography for the purification of His-tagged recombinant proteins. The histidine residues in the tag form

RNA once the cell is disrupted. Guanidinium thiocyanate is a powerful chaotropic agent that denatures proteins, including RNases, ensuring that the extracted RNA remains intact for downstream applications like gene expression analysis and sequencing.

64. (D) 50 μg/mL
In UV spectrophotometry, an absorbance reading of 1.0 at 260 nanometers corresponds to approximately 50 micrograms per milliliter of double-stranded DNA. This standard conversion factor allows for the rapid quantification of purified DNA samples. For other nucleic acids, the factors differ, with single-stranded DNA being approximately 33 micrograms per milliliter and RNA being approximately 40 micrograms per milliliter per absorbance unit.

65. (A) P-II, Q-I, R-IV, S-III
Nested PCR improves specificity by using two primer sets, while multiplex PCR amplifies several targets simultaneously. Reverse transcriptase PCR converts RNA into cDNA before amplification, and real-time PCR allows for the continuous monitoring of amplicon accumulation. These variants extend the utility of the basic PCR technique, enabling complex diagnostic and research applications across various fields of molecular biology and veterinary medicine.

66. (B) Restriction endonuclease
Restriction endonucleases are essential for generating the specific DNA fragments analyzed in restriction fragment length polymorphism assays. These enzymes recognize and cleave DNA at specific nucleotide sequences. Variations in these sequences between individuals result in fragments of different lengths. By comparing the resulting banding patterns after electrophoresis, researchers can identify genetic differences and determine relatedness in forensic and genomic studies.

67. (A) I, II and IV
Microsatellites are short tandem repeats found throughout eukaryotic genomes and are highly polymorphic, making them excellent markers for genetic studies. They are widely utilized for parentage verification and individual identification in animal breeding and forensics. While they are a staple of eukaryotic genetics, they are not a defining feature of prokaryotic genomes, which typically lack such extensive non-coding repetitive sequences.

68. (A) I
The standard sequence for probe hybridization involves initial binding of the labeled probe to the target sequence. This is followed by stringency washes, which use specific temperature and salt conditions to remove non-specific or weakly bound probes. Finally, the specific signal is detected using various methods such as autoradiography or chemiluminescence. This sequence ensures that only accurate, perfectly matched hybrids are visualized.

69. (C) Origin of replication (ori)
The origin of replication is a critical sequence element required for a plasmid vector to replicate autonomously within a bacterial host cell. This specific site is recognized by the host cell's replication machinery, initiating the duplication of the plasmid DNA. Without a functional origin, the plasmid would not be maintained through successive generations of cell division, regardless of other functional elements.

70. (B) It offers higher specificity since two distinct antibodies must bind the antigen.
A sandwich ELISA offers significantly higher specificity than a direct ELISA because it requires the target antigen to be recognized and bound by two distinct antibodies. The capture antibody immobilized on the plate and the detection antibody added later must both bind the antigen to generate a signal. This dual-binding requirement reduces background noise and ensures more accurate detection of the specific analyte.

71. (A) Both A and R are true and R is the correct explanation of A.
DNA microarrays are powerful tools that simultaneously analyze the expression levels of thousands of genes. This is achieved by utilizing immobilized arrays of specific nucleic acid probes on a solid surface. When fluorescently labeled target cDNA from a sample is applied, it hybridizes to the corresponding probes. The intensity of the resulting fluorescence at each spot reflects the abundance of specific transcripts.

72. (B) Quantum dots
Quantum dots are specialized semiconductor nanoparticles renowned for their size-tunable

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DNA to be amplified. These short, synthetic DNA sequences are designed to be complementary to the flanking regions of the target sequence. By binding to these specific sites, they provide the starting point for DNA polymerase to synthesize new strands, ensuring the selective enrichment of the desired fragment.

91. (A) P-II, Q-I, R-III, S-IV
EcoRI and BamHI create five-prime cohesive sticky ends, while PstI produces three-prime cohesive ends. SmaI is known for generating blunt ends by cutting directly across the DNA backbone. These different cleavage styles are fundamental to molecular cloning strategies, as they determine how various DNA fragments can be ligated together to create recombinant molecules with specific orientations and properties.

92. (A) It can definitively prove the exact age of an animal.
DNA fingerprinting in veterinary forensics is a powerful tool for identifying poached wildlife and resolving parentage disputes by analyzing highly polymorphic genomic regions. These regions provide unique profiles for individual animals. However, DNA sequences do not undergo predictable changes with age that can be measured with this technique. Consequently, while it confirms identity and lineage, it cannot definitively determine an animal's age.

93. (B) Depurination with dilute HCl
For efficient transfer of large DNA fragments during Southern blotting, a depurination step with dilute hydrochloric acid is required. This process breaks the DNA backbone into smaller, more manageable pieces by removing purine bases. Following depurination, the DNA is denatured with alkali. These steps ensure that high-molecular-weight fragments can leave the gel matrix and bind effectively to the membrane for subsequent hybridization.

94. (A) Both A and R are true and R is the correct explanation of A.
Expression vectors are specialized plasmids that contain regulatory sequences necessary for the transcription and translation of an inserted gene. Unlike standard cloning vectors, they include promoters, ribosome binding sites, and transcription terminators. These elements allow the host cell's machinery to produce the protein product of the foreign gene. This makes them essential for recombinant protein production in various biological systems.

95. (B) The specific target antigen
In an indirect ELISA for detecting antibodies, the surface of the microtiter plate well is coated with the specific target antigen. When the patient's serum is added, any target antibodies will bind to the immobilized antigen. A secondary enzyme-linked antibody is then used to detect the bound primary antibodies. This format is commonly used for diagnosing infectious diseases and monitoring immune responses.

96. (B) Time of Flight
In MALDI-TOF mass spectrometry, "TOF" stands for Time of Flight, which describes how ionized molecules are separated. After ionization, the molecules are accelerated through an electric field and enter a flight tube. Their mass-to-charge ratio determines the time it takes to reach the detector, with smaller ions traveling faster. This precise timing allows for the accurate measurement of molecular weights across a wide range.

97. (A) I, II and IV
Nanotechnology in diagnostics leverages materials with high surface-area-to-volume ratios and unique properties like localized surface plasmon resonance in gold nanoparticles. Magnetic nanoparticles are used to concentrate pathogens, improving detection sensitivity. However, not all nanomaterials are universally biocompatible or non-toxic. Their potential health and environmental impacts must be carefully evaluated despite their significant advantages in enhancing the speed and accuracy of diagnostic assays.

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98. (A) Cytosol and mitochondria
Increased serum levels of alanine aminotransferase and aspartate aminotransferase typically indicate injury to the cytosol and mitochondria. ALT is primarily found in the cytoplasm, while AST is present in both the cytoplasm and mitochondria. Significant release of these enzymes into the blood signifies hepatocellular or muscle cell damage, making them essential markers in clinical enzymology for identifying the severity of tissue injury.

Brilliant Blue dye. Detergents can cause the dye to precipitate or shift its absorbance independently of protein binding, leading to erroneously high and unreliable readings. When working with membrane proteins or lysis buffers containing detergents, alternative assays like the BCA method are preferred.

82. (B) The degree of separation between two adjacent peaks on the chromatogram
Resolution in chromatography refers to the degree of separation between two adjacent peaks on a chromatogram. It is a critical metric that considers both the peak width and the distance between the peak centers. Higher resolution indicates better separation, which is essential for accurate quantification and identification of components in complex mixtures. It is influenced by the efficiency and selectivity of the column.

83. (C) Thermal Conductivity Detector (TCD)
The thermal conductivity detector is essentially a non-destructive detector used in gas chromatography. It measures the change in thermal conductivity of the carrier gas as analytes emerge from the column. Unlike flame ionization detectors, which burn the sample, the TCD preserves the analytes, allowing them to be recovered for further analysis. This makes it highly versatile, although it is generally less sensitive.

84. (A) I and II
Affinity chromatography utilizes reversible biological interactions, such as enzyme-substrate or antibody-antigen binding, to achieve high-purity separations. A spacer arm is frequently attached to the matrix to provide distance between the ligand and the support, preventing steric hindrance and ensuring optimal binding. Elution typically requires changing buffer conditions, such as pH or ligand concentration, rather than using the original binding buffer.

85. (C) Molecular weight, net charge, and physical shape
During native polyacrylamide gel electrophoresis, proteins are separated based on their molecular weight, net charge, and physical shape. Because the proteins remain in their folded, non-denatured state, their migration speed is influenced by multiple factors simultaneously. This allows researchers to study protein-protein interactions, multi-protein complexes, and enzymatic activity directly within the gel matrix, unlike denaturing methods that only assess molecular weight.

86. (B) Dithiothreitol (DTT)
Dithiothreitol is a strong reducing agent used in SDS-PAGE to break intra- and inter-molecular disulfide bonds. By reducing these covalent linkages, the proteins are fully linearized and coated with SDS, ensuring that their separation is based solely on molecular weight. This step is essential for accurate size determination, especially for proteins that exist as multimeric complexes or contain multiple internal cross-links.

87. (B) Ionization of a gas within a sealed tube by incoming radiation
The Geiger-Müller counter operates by the ionization of a gas within a sealed tube when radiation enters. The resulting ions and electrons are accelerated by a high-voltage electric field, triggering an avalanche of further ionizations. This creates a detectable electrical pulse for every radiation event. While highly sensitive, it cannot distinguish between different types of radiation or measure their specific energy.

88. (A) II, III, I, IV
RNA purification begins with tissue homogenization in a denaturing lysis buffer to stabilize the RNA and inactivate RNases. Phase separation is then achieved using chloroform, partitioning the RNA into the aqueous layer. The RNA is recovered through isopropanol precipitation, and the resulting pellet is washed with ethanol to remove residual salts. This sequence ensures high-quality RNA for sensitive molecular biology procedures.

89. (B) Phenolate ions or chaotropic salts
A prominent absorbance peak at 230 nanometers during the UV spectrophotometric assessment of nucleic acids usually indicates contamination by phenolate ions or chaotropic salts. These substances are common reagents used in extraction protocols and can interfere with downstream enzymatic processes if not properly removed. Monitoring the $\frac{A_{260}}{A_{230}}$ ratio is essential for evaluating the overall chemical purity and suitability of the sample for experiments.

90. (D) Oligonucleotide primers
Oligonucleotide primers are the PCR components that dictate the specific region of the template

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108. (A) II, IV, I, III
A standard high-performance liquid chromatography system is organized starting with the pump, which drives the mobile phase. The sample is introduced via the injector, followed by the analytical column where separation occurs. Finally, the analytes are detected by the detector before the waste is collected. This logical sequence ensures a consistent flow and accurate measurement of the separated chemical components in a sample.

109. (A) III only
Sephadex and polyacrylamide gels are standard matrices used in size-exclusion chromatography, where cross-linking determines the fractionation range. However, claiming that agarose gels have small pores and are only for small peptides is incorrect. In fact, agarose gels like Sepharose have relatively large pores and are primarily used for the separation of large proteins, nucleic acids, and even whole viruses.

110. (C) It intercalates between base pairs and fluoresces under UV light for visualization.
Ethidium bromide is a fluorescent dye used in agarose gel electrophoresis to visualize DNA fragments. It functions by intercalating between the nitrogenous base pairs of the nucleic acid. When exposed to ultraviolet light, the bound dye fluoresces brightly, allowing researchers to see the location and intensity of DNA bands. This enables the assessment of fragment size and quantity in various molecular biology experiments.

111. (B) Its net charge becomes zero and it stops migrating.
During isoelectric focusing, a protein migrates through a pH gradient until it reaches the zone corresponding to its isoelectric point. At this specific pH, the protein's net electrical charge becomes zero, and it stops migrating in the electric field. This behavior allows for the precise separation of proteins based on their individual pI values, even if they have similar molecular weights.

112. (A) To absorb beta-particle energy from the solvent and emit light photons.
In liquid scintillation counting, the primary fluor absorbs the kinetic energy of beta particles that has been transferred to the solvent molecules. The fluor then converts this energy into light photons. These light flashes are detected and amplified by photomultiplier tubes. This mechanism allows for the sensitive measurement of low-energy radioactivity, which is common in many biological and biochemical tracer studies.

113. (C) RNase A
RNase A is commonly added during genomic DNA extraction protocols to specifically eliminate RNA contamination. This highly stable enzyme degrades all RNA molecules into small fragments, which are then easily removed during subsequent purification steps. Ensuring the absence of RNA is critical for accurate DNA quantification and for sensitive downstream applications such as restriction digestion, southern blotting, and polymerase chain reaction amplification.

114. (A) P-II, Q-I, R-IV, S-III
Pure DNA has a peak absorbance at 260 nanometers, while proteins peak at 280 nanometers. Background scatter and turbidity are typically corrected using readings at 320 nanometers. Organic solvent contamination, which affects sample purity, is assessed at 230 nanometers. Understanding these standard spectroscopic readings is fundamental for evaluating the concentration and quality of nucleic acid samples before performing complex molecular analyses.

115. (B) Processivity and half-life of Taq polymerase.
The maximum size of a DNA amplicon in standard PCR is primarily limited by the processivity and half-life of Taq polymerase. As the target sequence increases in length, the probability of the enzyme dissociating or becoming inactive before completing the strand increases. While specialized long-range PCR systems exist, standard protocols are typically optimized for fragments under five kilobases due to these enzymatic constraints.

116. (D) A silent mutation in an exon that does not alter any restriction site
Standard restriction fragment length polymorphism analysis cannot directly detect silent mutations that do not alter a restriction enzyme's recognition site. Because the technique relies on variations in fragment length produced by specific cleavages, any mutation that does not change the site or the distance between sites will remain invisible. Such molecular changes require

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99. (B) Dehydration causing reduced renal perfusion
Pre-renal elevation of blood urea nitrogen is most commonly caused by dehydration, which leads to reduced renal perfusion and a lower glomerular filtration rate. When blood flow to the kidneys is compromised, the excretion of urea decreases, causing it to accumulate in the bloodstream. This condition is distinguished from primary renal disease by the kidneys' retained ability to concentrate urine once perfusion is restored.

100. (C) Parathyroid hormone and Vitamin D regulation
A low serum calcium level combined with high phosphorus in a dog with chronic kidney disease points to dysfunction in parathyroid hormone and vitamin D regulation. The kidneys' inability to excrete phosphorus and activate vitamin D leads to secondary hyperparathyroidism. This complex endocrine imbalance is a classic feature of renal failure, resulting in bone mineral loss and further metabolic complications that require specialized clinical intervention.

101. (B) Monochromator
A monochromator is the component of a UV-Visible spectrophotometer that isolates a specific narrow band of wavelengths from a broad-spectrum light source. By using a prism or a diffraction grating, it disperses light into its component wavelengths and allows only the desired frequency to pass through the sample. This ensures that the absorbance measurements are performed with monochromatic light, as required by the Beer-Lambert law.

102. (C) Liquid solutions or fine suspensions aerosolized into the flame
When analyzing elements via flame photometry, samples must be in the form of liquid solutions or fine suspensions. These liquids are aerosolized by a nebulizer before being introduced into the flame. The heat then evaporates the solvent and atomizes the analytes. This liquid-handling requirement makes the technique well-suited for measuring alkali metal concentrations in biological fluids like serum and urine.

103. (A) P-II, Q-III, R-I, S-IV
Differential centrifugation provides crude fractionation of cell components, while rate-zonal centrifugation separates particles by size through a pre-formed gradient. Isopycnic centrifugation separates strictly by buoyant density. Analytical ultracentrifugation is used for the precise determination of molecular properties. These techniques are essential for isolating organelles and studying the physical characteristics of macromolecules in diverse biochemical and clinical research settings.

104. (C) Osmotic lysis
Osmotic lysis is a non-mechanical method of cell disruption that relies on placing cells in a hypotonic solution. The resulting water influx causes the cells to swell and burst due to internal pressure. In contrast, homogenization, sonication, and bead milling are all mechanical methods that use physical force or shearing to break cell boundaries, making them more suitable for tough or walled organisms.

105. (A) Concentration polarization
Concentration polarization is a phenomenon in ultrafiltration where retained macrosolutes accumulate at the membrane surface, creating a concentrated boundary layer. This layer increases resistance to flow and reduces the overall filtration rate. It can also lead to membrane fouling and altered molecular weight cut-off characteristics. Managing this effect through techniques like cross-flow filtration is essential for maintaining efficient separation and sample concentration.

106. (A) Both A and R are true and R is the correct explanation of A.
The bicinchoninic acid assay is highly reliable for samples containing up to five percent sodium dodecyl sulfate. Unlike the Lowry assay, which is easily disrupted by many ionic detergents, the BCA reagent is specifically formulated to be highly tolerant of these agents. This compatibility makes the BCA assay an indispensable tool for quantifying proteins in samples that require detergents for solubilization, such as membrane protein preparations.

107. (B) $\dfrac{\text{Distance traveled by solute}}{\text{Distance traveled by solvent front}}$
In thin-layer chromatography, the retention factor is calculated as the ratio of the distance traveled by the solute to the distance traveled by the solvent front. This dimensionless value is characteristic for a given substance under specific experimental conditions. It allows researchers to identify compounds by comparing their R_f values to known standards, facilitating qualitative analysis in pharmaceutical and biochemical research.

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fluorescence emission. By precisely controlling the size of the nanocrystal, researchers can tune the emitted light across the visible and infrared spectrum. Their high brightness and resistance to photobleaching make them exceptionally valuable in advanced biological imaging, allowing for the long-term tracking of molecules and cells within living organisms.

73. (B) Normal bone osteoblast activity
An isolated increase in serum alkaline phosphatase in a growing puppy is typically indicative of normal bone osteoblast activity. This enzyme is involved in the mineralization of bone tissue, and its levels are naturally higher during periods of rapid skeletal growth. In this context, the elevation is physiological rather than pathological, distinguishing it from hepatic or renal disease indicators seen in adult animals.

74. (C) Creatinine
Creatinine provides a reliable estimation of the glomerular filtration rate because it is freely filtered by the glomeruli and undergoes minimal reabsorption or secretion by the renal tubules. As a byproduct of muscle metabolism produced at a relatively constant rate, its blood concentration inversely reflects renal function. This makes creatinine a cornerstone marker for assessing kidney health and diagnosing various stages of azotemia.

75. (B) IV only
Vitamin diagnostics involve measuring various forms of these essential nutrients to assess animal health. Vitamin E deficiency leads to white muscle disease, while vitamin K is critical for prothrombin synthesis. Vitamin D levels are most accurately assessed by measuring serum 25-hydroxycholecalciferol, which is the major circulating form. Therefore, claiming that levels are assessed exclusively by measuring 1,25-dihydroxycholecalciferol is clinically incorrect and misleading.

76. (B) Absorption of the excitation or emission light by the sample itself at high concentrations
Inner filter effects in fluorimetry are primarily caused by the absorption of either the excitation or emission light by the sample itself. This occurs when the concentration of the fluorophore is so high that the light intensity is significantly attenuated as it passes through the cuvette. This phenomenon leads to non-linear calibration curves, necessitating sample dilution to ensure accurate and proportional measurements.

77. (C) Nitrous oxide-acetylene
The nitrous oxide-acetylene flame provides the highest temperature in flame photometry, typically reaching around three thousand degrees Celsius. This intense heat is necessary for atomizing elements that form stable oxides or have high melting points, such as aluminum and silicon. In contrast, cooler flames like air-propane are only suitable for easily atomized alkali metals like sodium and potassium in clinical samples.

78. (C) At the outermost bottom corner of the tube
In a fixed-angle centrifuge rotor, pelleted particles accumulate at the outermost bottom corner of the tube. The centrifugal force acts at an angle relative to the tube's axis, causing particles to move outward and then slide down the tube wall toward the bottom. This resulting pellet is often slightly asymmetric but provides a concentrated mass of material for collection or further processing.

79. (A) P-II, Q-IV, R-I, S-III
Lysozyme enzymatically degrades bacterial cell walls, while detergents solubilize lipid bilayers. Bead beating uses microparticles for the mechanical shearing of tough yeast or fungal walls. The French press utilizes high-pressure extrusion to cause rapid cell bursting. These diverse methods allow researchers to select the most appropriate technique based on the specific structure and resilience of the target organism's cellular boundaries.

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80. (C) Approximately half to one-third the molecular weight of the target protein
When concentrating proteins via ultrafiltration, the membrane's molecular weight cut-off should be approximately half to one-third the weight of the target protein. This ensures that the protein of interest is efficiently retained while allowing smaller contaminants and buffer components to pass through. Choosing a cut-off too close to the protein's weight can result in significant sample loss due to partial passage.

81. (A) Both A and R are true and R is the correct explanation of A.
The Bradford assay is incompatible with samples containing high concentrations of detergents because these agents interfere with the Coomassie

more sensitive methods, such as direct DNA sequencing, for detection.

117. (A) Both A and R are true and R is the correct explanation of A.
Microsatellites are preferred for modern DNA profiling because their short repeating units make them highly suitable for robust amplification via multiplex PCR. This is especially advantageous when working with degraded DNA samples common in forensic cases. Their high polymorphism and ease of analysis using automated sequencers have led them to replace older, more labor-intensive techniques like minisatellite-based restriction fragment length polymorphism.

118. (B) To denature RNA and prevent the formation of secondary structures
Formaldehyde or glyoxal is added to Northern blot gels to denature the RNA molecules. RNA has a strong tendency to form complex secondary and tertiary structures through internal base pairing, which would interfere with its separation by size. By maintaining the RNA in a linear, denatured state, these chemicals ensure accurate electrophoretic migration and efficient transfer to the membrane for subsequent hybridization.

119. (A) I, II, III and V
Bacteriophage lambda vectors accommodate larger inserts than plasmids and are packaged into phage heads in vitro. They infect bacteria via transduction and utilize the lytic cycle to produce visible plaques on a lawn. While highly versatile for cloning, they are not used exclusively for eukaryotic mRNA; instead, they are common tools for constructing genomic and cDNA libraries across various organisms.

120. (B) The affinity constant of the specific antibody
The sensitivity of a radioimmunoassay is fundamentally dictated by the affinity constant of the specific antibody used. A higher affinity constant indicates a stronger and more specific binding between the antibody and the antigen, allowing for the detection of lower concentrations of the analyte. While other factors like isotopic half-life are important, the antibody's binding characteristics set the ultimate detection limit.

121. (B) It cleaves proteins specifically at the C-terminal side of lysine and arginine residues to generate peptides.
In bottom-up proteomics, trypsin is used prior to LC-MS analysis to cleave proteins into smaller, manageable peptides. It specifically targets the carboxyl side of lysine and arginine residues, except when followed by proline. This predictable cleavage pattern generates a unique set of peptides for each protein, which are then separated and sequenced by mass spectrometry to identify the original proteins.

122. (C) Persistent metallic nanoparticles used as systemic imaging contrast agents
The use of persistent metallic nanoparticles as systemic imaging contrast agents poses the greatest theoretical risk of bioaccumulation. Unlike biodegradable liposomes, these inorganic materials may not be easily broken down or excreted by the body. Their long-term retention in tissues like the liver, spleen, and bone marrow raises concerns about potential chronic toxicity and interference with normal cellular functions over time.

123. (B) CK-MB
The creatine kinase isoenzyme CK-MB is predominantly found in cardiac muscle tissue. While skeletal muscle mainly contains the CK-MM form and brain tissue contains CK-BB, an elevation in the serum concentration of the MB fraction is a specific indicator of myocardial injury. This marker is valuable in both human and veterinary medicine for diagnosing heart muscle damage and distinguishing it from skeletal injury.

124. (A) I, II, III, IV
Severe diabetic ketoacidosis typically progresses from hyperglycemia due to insulin deficiency to increased lipolysis and the release of free fatty acids. These acids are then converted by the liver into ketone bodies, leading to a state of systemic metabolic acidosis. This sequence of metabolic changes reflects a profound shift in energy utilization and acid-base balance, necessitating urgent and comprehensive medical treatment.

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125. (A) P-III, Q-IV, R-I, S-II
Parathyroid hormone mobilizes calcium from bone, while cortisol mediates the stress response and promotes gluconeogenesis. Aldosterone regulates sodium and potassium balance, and

These enzymes can cause rapid browning and inactivation of proteins by oxidizing phenolic compounds into reactive quinones. PVP binds to these phenols, preventing them from interacting with and damaging the target enzymes. This step is crucial for maintaining the stability and activity of plant-derived proteins.

55. (A) It disrupts the hydration shell and denatures the protein, leading to aggregation.
Trichloroacetic acid precipitates proteins by disrupting their hydration shells and causing denaturation. The high acidity of TCA alters the electrostatic interactions and hydrophobic shielding within the protein structure, leading to the exposure of hydrophobic regions and subsequent aggregation. This technique is widely used in laboratories to concentrate protein samples and remove interfering small molecules before analysis or further purification steps.

56. (A) I and II
The bicinchoninic acid assay involves the reduction of divalent copper ions to monovalent ions by proteins in an alkaline medium. These monovalent ions then react with bicinchoninic acid to form a stable, purple-colored complex. The intensity of this color is measured at an absorbance of 562 nanometers. The assay is highly sensitive and tolerant to various common laboratory detergents, unlike many other methods.

57. (B) The buffer pH is set above the proteins' isoelectric points (pI).
In anion-exchange chromatography, the buffer pH must be set above the proteins' isoelectric points to ensure they carry a net negative charge. This negative charge allows the protein analytes to bind to the positively charged stationary phase matrix. By manipulating the pH, researchers can selectively bind and elute specific proteins based on their individual charge characteristics and isoelectric point values.

58. (A) Both A and R are true and R is the correct explanation of A.
High-performance liquid chromatography operates at high pressures because its stationary phase consists of extremely small particles. These small particles provide a large surface area for interactions, which significantly improves separation efficiency and resolution. However, they also create high resistance to mobile phase flow. High-pressure pumps are therefore necessary to drive the solvent through the column at reasonable and consistent flow rates.

59. (C) At the void volume (V_o)
In gel filtration chromatography, molecules larger than the pore exclusion limit are unable to enter the stationary phase beads. Consequently, they travel only through the spaces between the beads and elute in the void volume of the column. The void volume represents the minimum amount of mobile phase required to carry these large molecules from the injector to the detector.

60. (C) Logarithm of its molecular weight
The electrophoretic mobility of nucleic acids in an agarose gel is inversely proportional to the logarithm of their molecular weight. As DNA or RNA molecules increase in size, they encounter more resistance from the gel matrix and migrate more slowly. This mathematical relationship allows researchers to accurately estimate the size of unknown fragments by comparing their migration distances to a standardized ladder.

61. (D) The second dimension involves native, non-denaturing conditions.
Two-dimensional gel electrophoresis is a vital proteomic technique where proteins are first separated by their isoelectric point. The second dimension, however, typically utilizes denaturing SDS-PAGE to separate proteins by molecular weight. This combination provides exceptional resolution for complex protein mixtures, allowing for the separation of hundreds or thousands of individual spots on a single gel for analysis.

62. (B) Half-life
The half-life is a fundamental metric in radiochemistry that defines the time required for one-half of the radioactive atoms in a sample to undergo decay. This value is constant for a given isotope and is independent of the initial amount of material. Understanding half-life is crucial for determining the duration of radioactivity in clinical tracers, environmental monitoring, and laboratory safety protocols.

63. (B) To permanently inactivate endogenous RNases
During RNA extraction, guanidinium thiocyanate is added to the lysis buffer to permanently inactivate endogenous RNase enzymes. These enzymes are ubiquitous and can rapidly degrade

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coordinate covalent bonds with the metal ions, allowing the target protein to be selectively captured from complex mixtures. Elution is then achieved using imidazole, which competes for the metal binding sites, releasing the protein.

135. (B) The positive electrode (anode)
During SDS-PAGE, proteins are coated with sodium dodecyl sulfate, which imparts a uniform negative charge-to-mass ratio. Consequently, when an electric field is applied, all proteins migrate towards the positive electrode, also known as the anode. This uniform migration allows the gel matrix to separate the linearized proteins solely based on their molecular weight as they move through the pores.

136. (A) P-I, Q-III, R-II, S-IV
Pulse-field gel electrophoresis resolves large DNA, while capillary electrophoresis uses fused-silica tubes for rapid, high-resolution separation. Isoelectric focusing separates proteins by pI, and 2D-PAGE combines this with molecular weight separation. These diverse electrophoretic techniques are essential for modern biological analysis, providing researchers with various tools to resolve complex mixtures of proteins and nucleic acids with high precision and efficiency.

137. (C) Iodine-125 (125I)
Iodine-125 is a pure gamma emitter commonly used to label proteins and antibodies for radioimmunoassays. Its relatively long half-life and ease of conjugation to tyrosine residues make it a practical choice for laboratory applications. The gamma radiation it emits is easily detected and quantified using a solid-state scintillation counter, providing high sensitivity for measuring trace amounts of various biological analytes.

138. (A) I, II, III, IV, V
Plasmid DNA extraction via alkaline lysis follows a precise sequence: resuspending the bacterial pellet, adding lysis buffer, and then neutralizing with potassium acetate. This is followed by centrifugation to remove the precipitated genomic DNA and cellular debris. Finally, the plasmid DNA remaining in the supernatant is recovered through alcohol precipitation. This standardized method ensures high yields of purified plasmid for molecular biology.

139. (B) The ratio will falsely decrease, often below 1.5.
Phenol contamination in a DNA sample will cause a false decrease in the $\frac{A_{260}}{A_{280}}$ ratio, often dropping it well below 1.5. This happens because phenol absorbs very strongly at 280 nanometers, artificially inflating the denominator of the ratio. Monitoring this value is crucial for ensuring the purity of DNA, as residual phenol can inhibit enzymes and interfere with downstream applications like PCR.

140. (B) Using TaqMan probes with a fluorophore and quencher.
TaqMan probes ensure high specificity in qPCR by generating a fluorescent signal only when the probe hybridizes to the specific target sequence. The probe contains a fluorophore and a quencher; fluorescence is released only when the DNA polymerase cleaves the probe during amplification. This mechanism prevents the detection of non-specific products or primer dimers, providing a more accurate quantification of the target DNA.

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141. (A) Both A and R are true and R is the correct explanation of A.
RFLP analysis has been largely replaced by PCR-based microsatellite analysis because the latter is faster and more robust. RFLP requires large quantities of intact, high-molecular-weight DNA and involves the time-consuming processes of restriction digestion, electrophoresis, and Southern blotting. In contrast, PCR can amplify minute and even degraded samples, making it far more practical for modern forensic and genetic laboratories.

142. (B) Variable Number of Tandem Repeats
VNTR stands for Variable Number of Tandem Repeats, which refers to genomic regions where a specific DNA sequence is repeated multiple times in a head-to-tail fashion. The number of repeats varies between individuals, creating high levels of polymorphism. These regions are essential markers in DNA fingerprinting and genetic mapping, providing a basis for individual identification and the study of genetic diversity.

143. (B) It increases the stringency, washing away weakly bound, mismatched probes.
Decreasing the salt concentration in washing buffers increases the stringency of nucleic acid hybridization. Low salt levels destabilize the

212. (A) Visible light photons
Scintillation cocktails contain fluors that absorb the energy of radioactive particles and emit visible light photons. This light is then detected and amplified by photomultiplier tubes in a liquid scintillation counter. The amount of light produced is proportional to the energy and frequency of the radioactive decay events, allowing for the sensitive quantification of isotopes like tritium and carbon-14 in various biological and chemical samples.

213. (A) Promote phase separation and remove lipids
Chloroform is used in DNA extraction primarily to promote phase separation and remove lipids. When added to a phenol-containing mixture, chloroform increases the density of the organic phase, ensuring a sharp and stable interface with the upper aqueous layer. This allows for the clean recovery of the DNA-containing aqueous phase while sequestering denatured proteins and lipids into the organic layer or the interphase during purification.

214. (A) 2.0
Pure RNA typically exhibits an $\frac{A_{260}}{A_{280}}$ ratio of approximately 2.0. This value is slightly higher than the 1.8 ratio observed for pure DNA because uracil has a higher absorbance at 260 nanometers than thymine. Monitoring this ratio is essential for evaluating the quality of extracted RNA; lower values often indicate protein or phenol contamination, which can interfere with downstream applications like reverse transcription or sequencing.

215. (C) 72°C
The optimum extension temperature for Taq polymerase is approximately 72 degrees Celsius. At this temperature, the enzyme exhibits its highest catalytic activity, rapidly adding nucleotides to the three-prime end of the primers. While the enzyme is thermostable enough to survive higher denaturation temperatures, its processivity is maximized during the extension phase at 72 degrees, ensuring the efficient and accurate duplication of the target DNA sequence.

216. (A) Sequence length variations between restriction sites
RFLP fundamentally detects sequence length variations between restriction enzyme recognition sites. These differences arise from mutations that create or destroy sites or from insertions and deletions within the intervening sequences. By digesting DNA with specific enzymes and separating the resulting fragments by size, researchers can identify genetic polymorphisms. This technique was a cornerstone of early genetic mapping and DNA fingerprinting in humans and domestic animals.

217. (B) STRs
Microsatellites are also widely known as short tandem repeats. These consist of repetitive sequences of two to six base pairs that occur at many locations throughout the genome. Because the number of repeats is highly variable among individuals, they serve as excellent genetic markers. STR analysis is the standard method for DNA profiling and parentage testing in humans and animals due to its high resolution and ease of amplification.

218. (B) Northern blotting
The transfer of RNA from an electrophoresis gel to a membrane for detection is specifically called Northern blotting. This technique allows for the identification and quantification of specific RNA transcripts using labeled nucleic acid probes. It is fundamental for studying gene expression patterns and mRNA stability. The name is a play on Southern blotting, which is the analogous technique used for the detection of specific DNA sequences.

219. (B) Multiple unique restriction enzyme recognition sites
A polylinker, also known as a multiple cloning site, is a short region in a vector that contains multiple unique restriction enzyme recognition sites. These sites are strategically placed to allow for the easy insertion of foreign DNA fragments using a variety of enzymes. This versatility makes the vector a highly flexible tool for molecular cloning, enabling researchers to insert genes in specific orientations for expression or study.

220. (B) Specificity and sensitivity
The primary advantage of a sandwich ELISA is its exceptionally high specificity and sensitivity. This format requires the target antigen to be recognized by two distinct antibodies—a capture antibody and a detection antibody. This "sandwich" requirement ensures that the signal is generated only when the specific analyte is present, reducing background noise and allowing

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152. (C) Atomize the sample into ground-state free atoms
In Atomic Absorption Spectroscopy, the primary function of the flame is to atomize the liquid sample into ground-state free atoms. This process involves evaporating the solvent, breaking chemical bonds, and converting the analytes into a gaseous atomic state. These ground-state atoms are then capable of absorbing specific wavelengths of light from an external source, allowing for the sensitive and specific quantification of elements.

153. (A) Both A and R are true and R is the correct explanation of A.
Ultracentrifuges operate within a high vacuum chamber to eliminate air friction during high-speed rotation. At speeds exceeding one hundred thousand revolutions per minute, air resistance would generate significant heat, potentially damaging the sample and the rotor itself. The vacuum environment ensures that the rotor remains cool and operates efficiently, allowing for the stable sedimentation of small macromolecules and organelles.

154. (B) Acid phosphatase
Acid phosphatase is the classic marker enzyme used to verify the purity of isolated lysosomes during sub-cellular fractionation. This enzyme is highly concentrated within lysosomes and exhibits peak activity at an acidic pH. By measuring its activity in various centrifugal fractions, researchers can confirm the successful enrichment of lysosomes and assess the degree of contamination from other organelles like mitochondria or nuclei.

155. (C) Exposure of hydrophobic regions as water molecules are sequestered by the salt
During ammonium sulfate precipitation, high salt concentrations sequester water molecules away from the protein surfaces. This process disrupts the protective hydration shell, leading to the exposure of hydrophobic regions. These exposed patches then interact and aggregate, causing the proteins to "salt out" and precipitate from the solution. This reversible technique is widely used for the initial purification and concentration of various proteins.

156. (A) P-I, Q-II, R-III, S-IV
The Bradford assay utilizes Coomassie G-250, while the Lowry assay relies on the Folin-Ciocalteu reagent. The BCA assay uses bicinchoninic acid and copper to generate a colored product. UV spectrophotometry quantifies proteins by measuring absorbance at 280 nanometers. These diverse assays offer varying degrees of sensitivity and tolerance to contaminants, allowing researchers to choose the most appropriate method for their specific samples.

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157. (B) Silica gel
In standard normal-phase thin-layer chromatography, the stationary phase is typically a thin layer of silica gel coated on a glass or plastic plate. Silica gel is highly polar, which causes polar analytes to interact strongly and migrate slowly. The mobile phase is usually a less polar organic solvent. This combination effectively separates compounds based on their varying degrees of polarity and chemical properties.

158. (B) The highly polar compound
In reverse-phase high-performance liquid chromatography, the stationary phase is non-polar and the mobile phase is polar. Consequently, polar compounds have a higher affinity for the mobile phase and will elute from the column first. Non-polar compounds interact more strongly with the hydrophobic stationary phase and are retained longer. This is the opposite of normal-phase chromatography and is widely used for organic analysis.

159. (A) II and III
Gel filtration chromatography separates molecules by size as they pass through porous beads. Molecules smaller than the pores enter the matrix and are delayed, while larger molecules are excluded and elute earlier. This technique is highly effective for desalting protein solutions by delaying small salt ions while the large proteins pass through quickly. The exclusion limit defines the largest, not the smallest, molecule that can enter.

160. (C) Marine red algae (seaweed)
Agarose is a linear polysaccharide that is primarily extracted from certain species of marine red algae, also known as seaweed. It is a purified component of agar, valued for its ability to form stable, porous gels when cooled from a liquid state. This property makes it the ideal matrix for the electrophoretic separation of large

correct for variations in flame stability, sample viscosity, and nebulization rates. By measuring the ratio of the analyte's emission to the internal standard's emission, errors caused by instrumental fluctuations are minimized. This technique significantly improves the precision and accuracy of measurements for sodium and potassium in clinical diagnostic laboratories.

178. (A) I and II
Isopycnic density gradient centrifugation separates particles strictly according to their buoyant density. Cesium chloride is commonly used to create these gradients, enabling the separation of DNA based on its specific GC content. Unlike rate-zonal centrifugation, the process is independent of time once equilibrium is reached, meaning particles will not pellet even with extended centrifugation, as they remain at their buoyant density.

179. (A) Triton X-100 or Nonidet P-40
Mild non-ionic detergents like Triton X-100 or Nonidet P-40 are frequently used to permeabilize eukaryotic cell membranes. These agents solubilize the plasma membrane by disrupting lipid interactions while leaving the more resilient nuclear envelope largely intact. This selective lysis is essential for isolating nuclei or studying cytoplasmic components without contaminating the sample with genomic DNA, facilitating various sub-cellular and molecular studies.

180. (A) P-II, Q-III, R-I, S-IV
Simple dialysis is driven by a concentration gradient, while electrodialysis utilizes an electrical potential. Ultrafiltration relies on a hydrostatic pressure gradient, and diafiltration involves continuous buffer exchange under pressure. These diverse methods allow for the efficient purification, concentration, and buffer exchange of various macromolecular samples by selecting the most appropriate driving force for the specific laboratory or industrial application.

181. (A) To facilitate the formation of the complex between Cu^{2+} and the peptide bonds
The Biuret assay requires an alkaline environment to facilitate the formation of a coordination complex between divalent copper ions and the nitrogen atoms of the peptide bonds. In the presence of sodium hydroxide, the copper ions react with the peptide linkages to produce a characteristic violet color. Without these basic conditions, the complex will not form, and the protein quantification cannot be performed.

182. (A) Both A and R are true and R is the correct explanation of A.
Thorough equilibration of the matrix in ion-exchange chromatography is essential before loading the sample. This process ensures that the functional groups on the stationary phase are fully charged and associated with the correct counter-ions. Proper equilibration establishes a consistent chemical environment, which is necessary for optimal and reproducible protein binding, ensuring that separation is based solely on the analytes' charge characteristics.

183. (A) A high-boiling liquid immobilized on a solid inert support
In gas-liquid chromatography, the stationary phase consists of a high-boiling liquid that is immobilized on a solid inert support or the inner wall of a capillary column. Separation is achieved as the volatile analytes partition between the gaseous mobile phase and this liquid stationary phase. The components' differing affinities and vapor pressures determine their migration speed, allowing for the high-resolution separation of complex mixtures.

184. (D) Oligo(dT) cellulose
Oligo(dT) cellulose is the most appropriate ligand in affinity chromatography for purifying messenger RNA from total cellular RNA. Most eukaryotic mRNA molecules possess a poly(A) tail that specifically hybridizes to the thymidine residues on the matrix. By using this specific base-pairing interaction, researchers can selectively capture mRNA while allowing other RNA types, like ribosomal or transfer RNA, to pass through the column.

185. (B) The total percentage of acrylamide and the ratio of bis-acrylamide cross-linker
The pore size of an SDS-PAGE resolving gel is determined by the total percentage of acrylamide and the specific ratio of the bis-acrylamide cross-linker. Higher concentrations of acrylamide result in smaller pores, which are better for separating small proteins. By adjusting these concentrations, researchers can optimize the gel's resolution to suit the molecular weight range of the target proteins in their specific samples.

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169. (B) YACs contain telomeric and centromeric sequences.
Yeast artificial chromosomes are distinguished from standard bacterial plasmids by the presence of telomeric and centromeric sequences. These elements allow the YAC to function like a true chromosome within a yeast host, ensuring stable replication and segregation of extremely large DNA inserts. While they also contain origins and markers, these structural components are essential for their massive carrying capacity and chromosomal stability.

170. (A) Insufficient washing after adding the primary antibody
In an indirect ELISA, a false positive result could most likely be caused by insufficient washing after the addition of the primary antibody. If residual antibodies remain in the well, they will be detected by the enzyme-linked secondary antibody, generating a signal even in the absence of the specific antigen. Proper washing is critical for removing unbound components and ensuring that the final colorimetric signal accurately reflects binding.

171. (A) Electrospray Ionization (ESI)
Electrospray ionization is the most common technique paired with liquid chromatography for complex proteome sequencing via tandem mass spectrometry. ESI allows for the continuous ionization of liquid samples as they emerge from the chromatography column, producing multiply charged ions. This seamless integration enables the high-throughput identification and sequencing of thousands of peptides in a single run, making it a cornerstone of modern proteomics.

172. (A) Both A and R are true and R is the correct explanation of A.
Nanoparticles are capable of crossing the blood-brain barrier more effectively than many traditional drugs due to their small size and specific surface functionalization. By attaching ligands that target receptors on the brain endothelial cells, nanoparticles can exploit transcytosis pathways to gain entry. This capability offers significant potential for delivering therapeutic agents to the central nervous system to treat various neurological conditions in animals.

173. (B) Creatine Kinase (CK)
When serum aspartate aminotransferase is elevated, creatine kinase must also be evaluated to determine if the source is skeletal muscle. While AST is found in both liver and muscle, CK is highly specific to muscle tissue. Concurrent elevation of both enzymes strongly suggests muscle injury, whereas an increase in AST alone, especially with elevated alanine aminotransferase, is more indicative of hepatocellular damage.

174. (B) Disproportionately high elevation of both BUN and Creatinine with hyperkalemia
Post-renal azotemia, often caused by a blocked urethra or ruptured bladder, is characterized by a disproportionately high elevation of both blood urea nitrogen and creatinine along with hyperkalemia. These findings occur because the waste products are either not excreted or are reabsorbed from the abdomen. The clinical presentation is typically acute and requires immediate intervention to relieve the obstruction and correct electrolyte imbalances.

175. (A) I, II, III, IV
The diagnostic sequence for feline hyperthyroidism begins with observing clinical signs such as weight loss and polyphagia. This is followed by measuring total serum thyroxine. If the results are borderline, free thyroxine measurement by equilibrium dialysis provides a more sensitive assessment. Once the diagnosis is confirmed, appropriate therapy can be initiated. This systematic approach ensures accurate identification and management of this common feline endocrine disorder.

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176. (B) Electrostatic interactions between analyte molecules alter their molar absorptivity.
At high analyte concentrations, the Beer-Lambert law often fails because electrostatic interactions between neighboring molecules can alter their molar absorptivity. As molecules become crowded, their electron distributions are affected, changing how they interact with light. These chemical deviations, along with instrumental factors, lead to a non-linear relationship between absorbance and concentration, necessitating the dilution of samples into the linear range.

177. (B) To correct for variations in flame stability, sample viscosity, and nebulization rate
In flame photometry, adding an internal standard like lithium allows researchers to

sites, fewer sample antigens allow more labeled antigens to bind. This results in more enzyme activity and a more intense color, reflecting the inverse relationship between signal and analyte concentration.

195. (A) I, II and III
Microarrays are used to compare gene expression profiles between different tissues by hybridizing labeled cDNA to a solid array of probes. In two-color microarrays, samples are labeled with distinct fluorophores, and the ratio of their intensities at each spot reveals relative expression levels. While powerful for transcriptomics, microarrays are not used for sequencing unknown genomes; instead, they rely on pre-existing sequence information to design the immobilized probes.

196. (B) Mass Spectrometry
Mass spectrometry is an analytical technique that involves ionizing chemical species and sorting the resulting ions based on their mass-to-charge ratio. By measuring the abundance of these ions, researchers can determine molecular weights, identify unknown compounds, and elucidate chemical structures. This technique is highly sensitive and versatile, finding extensive applications in proteomics, metabolomics, and forensic toxicology across various scientific and clinical fields.

197. (A) I, II, III, IV
A standard proteomics workflow begins with protein extraction and purification, followed by tryptic digestion into peptides. These peptides are then separated using liquid chromatography before undergoing tandem mass spectrometry for sequencing. Finally, database searching identifies the original proteins based on the peptide sequences. This bottom-up approach provides comprehensive profiles of complex proteomes, enabling the identification and quantification of thousands of individual proteins.

198. (A) Nanoencapsulation in solid lipid nanoparticles
Nanoencapsulation in solid lipid nanoparticles is an application of nanotechnology aimed at improving the bioavailability of poorly water-soluble veterinary drugs. By incorporating these drugs into a lipid-based nanoparticle, their solubility and stability in the gastrointestinal tract are enhanced, allowing for more efficient absorption. This technology provides a platform for delivering a wide range of therapeutic agents more effectively, reducing dosage requirements and potential side effects.

199. (B) Biliary tract disease (cholestasis)
A significant increase in serum gamma-glutamyl transferase in a cow is a highly specific indicator of biliary tract disease or cholestasis. This enzyme is primarily associated with the biliary epithelium, and its elevation reflects obstruction or injury to the bile ducts. In ruminants, GGT is more reliable than alkaline phosphatase for identifying cholestatic disease, making it a critical marker in bovine clinical biochemistry and hepatic evaluation.

200. (A) P-III, Q-II, R-I, S-IV
Blood urea nitrogen is a byproduct of protein metabolism used to assess renal function, while creatinine specifically reflects glomerular filtration. Glucose serves as the primary energy substrate under tight hormonal control. Ketone bodies are products of incomplete fat metabolism during states of negative energy balance. Understanding these markers' physiological significance is essential for diagnosing metabolic and renal diseases in clinical veterinary practice and research.

201. (A) L mol-1 cm-1
The molar extinction coefficient is a fundamental constant in spectrophotometry that expresses how strongly a substance absorbs light at a specific wavelength. It is defined by the Beer-Lambert law and is typically expressed in units of liters per mole per centimeter. This value allows researchers to calculate the exact concentration of a solute in a solution from its measured absorbance and the light's path length.

202. (A) Nitrous oxide-Acetylene
The nitrous oxide-acetylene mixture produces the hottest flame used in flame photometry and atomic absorption spectroscopy. Reaching temperatures of approximately three thousand degrees Celsius, this flame provides sufficient energy to atomize elements that form refractory oxides, which cooler flames cannot break down. This capability is essential for the accurate analysis of elements like aluminum, silicon, and titanium in various industrial and biological samples.

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186. (B) Incomplete solubilization or poor focusing during the first-dimension IEF
Horizontal streaking in 2D gel electrophoresis is an artifact commonly caused by incomplete protein solubilization or poor focusing during the first-dimension isoelectric focusing step. If proteins are not properly linearized or if the pH gradient is unstable, they will not reach a sharp isoelectric point, leading to broad, smeared spots in the second dimension. Ensuring thorough sample preparation and optimal focusing conditions is essential for clear results.

187. (A) I, II and III
Quenching in liquid scintillation counting reduces efficiency through various mechanisms. Color quenching involves the absorption of emitted light by the sample itself, while chemical quenching occurs when energy is absorbed before it can excite the fluor. These phenomena interfere with accurate radioactivity measurement, requiring the use of quenching correction methods to ensure that the final data truly reflects the amount of radioactivity present.

188. (A) I, II, III, IV, V
A typical Northern blot procedure begins with RNA extraction and quantification, followed by electrophoresis through a denaturing agarose gel. The RNA is then transferred to a nylon membrane and fixed using UV cross-linking. Finally, hybridization with a labeled probe allows for the detection of specific RNA sequences. This sequence of steps ensures that RNA molecules are separated by size and accurately identified through specific binding.

189. (B) Pure DNA
An $\frac{A_{260}}{A_{280}}$ ratio of 1.8 is the hallmark of a pure DNA sample in UV spectrophotometry. This value indicates that the sample is free from significant protein or phenol contamination, which would lower the ratio. Achieving this level of purity is essential for the success of many molecular biology techniques, as contaminants can inhibit enzymes and interfere with accurate quantification and subsequent experimental results.

190. (A) P-II, Q-III, R-IV, S-I
Quantitative PCR uses fluorescent dyes for monitoring, while reverse transcriptase PCR requires the specific enzyme to convert RNA to cDNA. Inverse PCR allows for the amplification of unknown flanking sequences, and asymmetric PCR generates single-stranded DNA by using unequal primer concentrations. These specialized variants provide diverse tools for addressing complex questions in molecular research, diagnostics, and the study of genomic architecture.

191. (A) Both A and R are true and R is the correct explanation of A.
Restriction enzymes like BamHI and EcoRI create sticky ends, which are short, single-stranded overhangs at the site of DNA cleavage. These ends are highly useful in cloning because they can easily form hydrogen bonds with complementary overhangs produced by the same enzyme. This base-pairing facilitates the action of DNA ligase, ensuring that the fragments are joined efficiently and in the correct orientation for recombination.

192. (A) Modern microsatellite DNA profiling
Modern microsatellite DNA profiling utilizes fluorescently labeled primers and capillary electrophoresis to determine the exact length of short tandem repeats. This highly automated technique provides single-base-pair resolution, allowing for the precise identification of different alleles at multiple loci simultaneously. Its high sensitivity and accuracy have made it the standard method for individual identification, parentage testing, and forensic analysis in both humans and domestic animals.

193. (B) To induce blue/white screening for identifying recombinant colonies
In molecular cloning, IPTG and X-gal are added to agar plates to facilitate blue/white screening when using vectors like pUC19. IPTG induces the expression of the beta-galactosidase gene, while X-gal is a substrate that turns blue when cleaved. Recombinant colonies, where the gene is disrupted by an insert, appear white, whereas non-recombinant colonies appear blue. This visual marker allows for the rapid identification of successful clones.

194. (B) A lower concentration of the target antigen in the patient sample
In a competitive ELISA, a stronger final colorimetric signal indicates a lower concentration of the target antigen in the patient sample. Because the sample antigen competes with a fixed amount of labeled antigen for binding

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hydrogen bonds between the probe and the target DNA. This ensures that only perfectly matched hybrids remain bound, while weakly bound or mismatched probes are washed away. Maintaining high stringency is critical for achieving high specificity and reducing background noise in blotting experiments.

144. (A) P-I, Q-II, R-III, S-IV
Plasmids typically hold up to ten kilobases, while bacteriophage lambda carries up to twenty-five. Cosmids, combining features of both, accommodate up to forty-five kilobases. Yeast artificial chromosomes have the highest capacity, exceeding one thousand kilobases. This progression in carrying capacity allows researchers to select the most appropriate vector for tasks ranging from single-gene cloning to the construction of entire genomic libraries.

145. (B) To prevent non-specific binding of antibodies to the plastic well surface
The blocking step in an ELISA is essential to prevent the non-specific binding of antibodies to any remaining open sites on the plastic well surface. By using proteins like BSA or non-fat dry milk, the surface is fully coated, ensuring that subsequent antibodies only bind to the specific target antigen. This significantly reduces background noise and improves the overall sensitivity and accuracy of the assay.

146. (A) Transcriptomics via DNA microarrays
DNA microarrays are the cornerstone of transcriptomics, utilizing labeled cDNA hybridized to thousands of microscopic spots of specific oligonucleotides. This technology allows for the simultaneous measurement of the expression levels of many genes in a single experiment. By comparing fluorescence intensities, researchers can identify which genes are up-regulated or down-regulated under different biological conditions, providing a comprehensive view of cellular transcription.

147. (A) I, II and III
Liposomes are versatile nanoparticle delivery systems composed of spherical lipid bilayers. They are exceptionally effective because they can encapsulate hydrophilic drugs within their aqueous core and incorporate hydrophobic drugs within the lipid bilayer itself. This dual capacity, combined with their biocompatibility and ability to be functionalized for targeting, makes them a primary choice for enhancing the delivery and efficacy of various therapeutic agents.

148. (A) Exogenous or endogenous corticosteroids (e.g., Cushing's disease)
In adult dogs, exogenous or endogenous corticosteroids are a common non-hepatic cause of elevated serum alkaline phosphatase. Corticosteroids induce a specific isoenzyme of ALP in the liver, leading to significantly increased serum activity. This finding is often associated with Cushing's disease or the administration of steroid medications. Distinguishing this corticosteroid-induced elevation from primary liver disease is essential for accurate clinical diagnosis.

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149. (B) Beta-hydroxybutyrate (BHB)
Measuring beta-hydroxybutyrate is a more reliable indicator of energy balance and early subclinical ketosis in ruminants than blood glucose. As the primary ketone body produced during negative energy balance, BHB levels rise significantly before clinical signs appear. This allows for the early detection and management of metabolic disorders in dairy cattle, ensuring better health and productivity compared to relying on fluctuating glucose measurements.

150. (A) I, III, II, IV
A standard indirect competitive radioimmunoassay begins with adding the patient sample containing unlabeled hormone, followed by a known amount of radiolabeled hormone. A fixed amount of specific antibody is then added to facilitate competition for binding sites. Finally, the bound and free hormones are separated and the radioactivity is counted. This sequence allows for the accurate quantification of hormone levels in biological samples.

151. (A) Beer-Lambert Law
The Beer-Lambert law describes the exponential decrease in light intensity as it passes through an absorbing medium. It establishes a linear relationship between absorbance and the concentration of the absorbing substance, as well as the path length of the light. This fundamental principle is the basis for most quantitative spectrophotometric analysis in chemistry and biology, allowing for precise measurements of solute concentrations.

203. (A) Sedimentation velocity per unit of centrifugal field
The sedimentation coefficient, expressed in Svedberg units, is defined as the sedimentation velocity of a particle per unit of centrifugal field. It reflects the physical properties of the particle, including its mass, density, and shape, as well as the properties of the medium. This parameter is used in ultracentrifugation to characterize the size and hydrodynamic behavior of macromolecules, organelles, and viruses during separation.

204. (C) Nitrogen cavitation
Nitrogen cavitation is a gentle method of cell disruption that involves equilibrating a cell suspension with nitrogen gas under high pressure. When the pressure is suddenly released, the nitrogen gas expands rapidly within the cells, causing them to burst. This technique is valued for its ability to preserve the integrity of organelles and proteins, as it avoids the intense heat and shear forces associated with sonication.

205. (A) Regenerated cellulose
Dialysis tubing is typically made from regenerated cellulose, a semi-permeable material with specific molecular weight cut-off properties. This material allows for the diffusion of small solutes and ions while retaining larger macromolecules like proteins and nucleic acids. Its chemical compatibility and defined pore sizes make it a standard tool for desalting, buffer exchange, and sample purification in biochemical and clinical laboratory research.

206. (C) 595 nm
The Bradford assay depends on the shift in the absorbance maximum of Coomassie Brilliant Blue G-250 dye when it binds to proteins. In an acidic solution, the dye normally absorbs at 465 nanometers. Upon binding to the basic and aromatic amino acid residues of proteins, the absorbance maximum shifts to 595 nanometers. This increase in absorbance is measured to quantify the total protein concentration in a sample.

207. (B) Polar
In normal-phase chromatography, the stationary phase is composed of a polar material, such as silica gel or alumina. This phase interacts more strongly with polar analytes, causing them to be retained longer on the column. The mobile phase used is typically non-polar. This traditional chromatographic approach is used for separating and purifying various organic molecules based on their differing polarities and chemical functional groups.

208. (B) ECD
The electron capture detector is highly sensitive to halogen-containing compounds, making it an essential tool for the trace analysis of pesticides and environmental pollutants. The detector works by measuring the decrease in standing current as electronegative atoms, such as chlorine or fluorine, capture thermal electrons. This high specificity allows for the detection of minute concentrations of halogenated substances in complex biological or environmental samples.

209. (A) Molecular size and shape
Gel filtration, or size-exclusion chromatography, separates molecules based primarily on their molecular size and shape. As a mixture passes through a column of porous beads, smaller molecules enter the pores and are delayed, while larger molecules are excluded and travel quickly through the void volume. This separation allows for the effective fractionation of proteins and nucleic acids and is also used for desalting macromolecular solutions.

210. (B) Charge-to-mass ratio
In SDS-PAGE, proteins are coated with sodium dodecyl sulfate, which provides them with a uniform negative charge-to-mass ratio. This treatment denatures the proteins and masks their original charges, ensuring that they migrate through the polyacrylamide gel solely based on their size. This standardized relationship allows for the accurate estimation of molecular weights by comparing sample migration to a known protein ladder under denaturing conditions.

211. (D) Ampholytes
Isoelectric focusing relies on a stable pH gradient established across a gel using carrier ampholytes. These are small, amphoteric molecules with varying isoelectric points that migrate to their respective pI positions when an electric field is applied. This creates a continuous pH gradient, allowing proteins to migrate until they reach the specific pH where their net charge is zero. This technique provides high resolution for complex protein mixtures.

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nucleic acids and proteins in molecular biology laboratories worldwide.

161. (A) I, II, III, IV, V
Two-dimensional gel electrophoresis follows a strict sequence: rehydrating the strip with the sample, performing isoelectric focusing, and then equilibrating the strip in SDS buffer. Next, the proteins are separated by molecular weight on an SDS-PAGE gel before final staining to visualize the resulting spots. This comprehensive workflow provides high-resolution mapping of complex proteomes, allowing for the detailed analysis of individual protein expression.

162. (A) Both A and R are true and R is the correct explanation of A.
Geiger-Müller counters are unable to determine the specific energy or type of incoming radiation. Every radiation event that enters the tube triggers a complete avalanche discharge of constant amplitude, regardless of the particle's initial energy. This "all-or-nothing" response makes the GM counter highly sensitive for detecting radioactivity but limits its utility for spectroscopic analysis compared to detectors that produce energy-proportional signals.

163. (A) High concentrations of chaotropic salts
In silica-based spin column DNA extraction, DNA binds to the silica membrane only in the presence of high concentrations of chaotropic salts like guanidine. These salts disrupt the hydration shell of the DNA, allowing it to form a bridge with the silica surface through hydrogen bonding and electrostatic interactions. Once contaminants are washed away, the purified DNA is eluted using a low-salt buffer or water.

164. (C) It increases by approximately 30-40% (Hyperchromic effect)
When double-stranded DNA is denatured into single strands, its UV absorbance at 260 nanometers increases by approximately thirty to forty percent, a phenomenon known as the hyperchromic effect. This occurs because the stacking of the nitrogenous bases in the double helix suppresses their light absorption. Upon denaturation, the bases are exposed and can absorb light more efficiently. This shift is used to monitor DNA denaturation.

165. (A) DNA template, primers, dNTPs, Taq, and Mg2+.
The extension phase of a PCR reaction requires several absolute components: a DNA template, specific primers, deoxynucleotide triphosphates, Taq polymerase, and magnesium ions. Magnesium serves as a critical cofactor for the polymerase enzyme. During this phase, the enzyme adds nucleotides to the primers, extending the new DNA strands across the target sequence. This systematic process is repeated to achieve exponential amplification of the DNA.

166. (A) P-I, Q-II, R-III, S-IV
RFLP detects the presence or absence of restriction sites, while SNPs represent single base-pair variations. VNTRs are long repetitive sequences, and STRs are short repetitive blocks. These diverse genetic markers provide different levels of resolution for genomic analysis. Understanding their defining mechanisms is essential for choosing the correct tool for forensic identification, genetic mapping, and the study of hereditary diseases in various animal species.

167. (A) Mendelian co-dominant inheritance of repeat alleles
The biological basis for using microsatellites in parentage testing is the Mendelian co-dominant inheritance of repeat alleles. An individual inherits one allele from each parent at every microsatellite locus. Because these loci are highly polymorphic, with many possible allele sizes in a population, comparing the profiles of the offspring and potential parents can definitively confirm or exclude biological relationships with high statistical confidence.

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168. (A) II and III
Formamide is used in hybridization buffers to lower the melting temperature of nucleic acid duplexes, allowing for specific binding at lower experimental temperatures. Probes with high GC content require higher temperatures or lower formamide concentrations because their triple hydrogen bonds are more stable. However, RNA-RNA hybrids are generally more stable than DNA-DNA hybrids, which is why Northern blotting conditions are often more stringent than Southern blotting.

for the detection of minute concentrations of the target in complex biological samples.

221. (B) Time to reach the detector in a flight tube
MALDI-TOF mass spectrometry separates ions based on their time of flight to reach the detector through a flight tube. After the ions are accelerated by an electric field, their mass-to-charge ratio determines their velocity. Smaller ions travel faster and reach the detector earlier than larger ones. This precise timing allows for the accurate determination of molecular weights for proteins, peptides, and other biomolecules with very high resolution.

222. (C) Localized Surface Plasmon Resonance
Gold nanoparticles exhibit unique optical properties due to a phenomenon called localized surface plasmon resonance. When exposed to light, the conduction electrons on the nanoparticle's surface oscillate collectively. This results in the strong absorption and scattering of specific wavelengths, giving gold nanoparticles their characteristic vibrant colors. These properties are exploited in various diagnostic assays, providing a visible read-out without the need for complex detection equipment.

223. (A) Skeletal muscle
Aspartate aminotransferase is found in high concentrations in both liver tissue and skeletal muscle. Because it is not liver-specific, elevated serum activity must be interpreted alongside other enzymes. If alanine aminotransferase is normal while AST is high, the source of the enzyme is more likely to be skeletal or cardiac muscle injury. This dual distribution makes it a versatile marker for both hepatic and muscular pathologies in veterinary medicine.

224. (A) Insulin and glucagon
Normal blood glucose levels are primarily maintained through the antagonistic actions of the hormones insulin and glucagon. Insulin promotes the cellular uptake and storage of glucose, effectively lowering blood sugar levels after a meal. Glucagon stimulates the liver to release glucose into the blood when levels are low, such as during fasting. Together, these pancreatic hormones ensure a stable supply of energy to the body's tissues.

225. (B) Serum ionized calcium
A primary indicator of hypocalcemia is a low level of serum ionized calcium. Ionized calcium is the biologically active fraction of the total calcium in the blood and is more clinically significant than total calcium, which can be influenced by protein levels. Measuring ionized calcium allows for the accurate assessment of calcium status in conditions like milk fever in cattle or eclampsia in dogs, ensuring appropriate treatment.

226. (B) Longer than the excitation wavelength
In fluorimetry, the emission wavelength is always longer than the excitation wavelength. This energy difference, known as the Stokes shift, occurs because some of the absorbed energy is lost through vibrational relaxation before the fluorophore emits a photon. This shift is crucial for fluorescence detection, as it allows for the effective filtering of the excitation light, enabling the sensitive and specific measurement of the emitted fluorescence.

227. (B) The same element being analyzed
Hollow cathode lamps are specific to Atomic Absorption Spectroscopy because the cathode is made of the same element being analyzed. When the lamp is energized, the excited atoms of that element emit characteristic spectral lines. These lines are precisely the same wavelengths that ground-state atoms of that element in the sample will absorb, ensuring high specificity and sensitivity for detecting the target element in complex mixtures.

228. (A) Titanium or aluminum alloys
Ultracentrifuge rotors are typically constructed from high-strength titanium or aluminum alloys to withstand the enormous centrifugal forces generated at high speeds. These materials offer the necessary durability and light weight to safely exceed speeds of one hundred thousand revolutions per minute. The choice of material is critical for ensuring the safety of the laboratory and the stability of the sedimentation process during the isolation of macromolecules.

229. (B) Liquid shear forces
Dounce homogenizers disrupt cells through the application of liquid shear forces. As a tight-fitting glass pestle is moved within a glass tube, the cell suspension is forced through a narrow clearance. This action creates intense turbulence and shear that breaks open the cell membranes

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intensities at each spot reveals which genes are more highly expressed in one sample compared to the other, providing a comprehensive profile of differential gene expression.

247. (B) Amphiphilic and biodegradable
Liposomes are highly effective drug carriers because they are amphiphilic and biodegradable. Their structure, composed of lipid bilayers surrounding an aqueous core, allows them to transport both hydrophilic and hydrophobic therapeutic agents. Being made of natural phospholipids, they are easily broken down by the body's metabolic processes, minimizing toxicity and ensuring the safe delivery and release of drugs within living systems in both human and veterinary medicine.

248. (C) Highly significant due to the very short enzyme half-life in cats
Elevations in serum alkaline phosphatase in cats are highly significant because the enzyme has an exceptionally short half-life in this species, lasting only about six hours. In contrast to dogs, where ALP levels can rise due to various causes, any increase in a cat strongly suggests active hepatobiliary disease or hyperthyroidism. This makes ALP a very sensitive, though less frequently elevated, marker for identifying significant pathology in feline clinical diagnostics.

249. (A) Acetyl-CoA
Acetyl-CoA is not considered a ketone body; rather, it is the primary metabolic precursor used by the liver to synthesize them. The three true ketone bodies are acetoacetate, beta-hydroxybutyrate, and acetone. These molecules are produced during periods of low glucose availability or insulin deficiency, serving as an alternative energy source for tissues like the brain and muscle. Their accumulation in the blood leads to the clinical condition known as ketosis.

250. (B) Cortisol levels before and after dexamethasone suppression
Diagnosis of hyperadrenocorticism, also known as Cushing's disease, typically involves measuring cortisol levels before and after a dexamethasone suppression test. In a healthy animal, dexamethasone provides negative feedback that lowers cortisol production. However, in an animal with Cushing's, the adrenal glands continue to produce high levels of cortisol. This diagnostic protocol is essential for confirming the disease and distinguishing between its pituitary-dependent and adrenal-dependent forms in veterinary patients.

251. (A) Absorbs UV or visible light
A chromophore is the specific part of a molecule that is responsible for absorbing ultraviolet or visible light. These structures often contain conjugated double bonds or aromatic rings that interact with light at specific wavelengths. The presence of a chromophore allows the molecule to be quantified via spectrophotometry. In biochemistry, many molecules, such as proteins and nucleic acids, possess natural chromophores that facilitate their detection and analysis in various research applications.

252. (A) Zeeman background correction
Spectral interferences in Atomic Absorption Spectroscopy are best minimized using Zeeman background correction. This technique utilizes a powerful magnetic field to split the atomic energy levels, allowing for the accurate measurement and subtraction of non-specific background absorption from the total signal. This ensures that the final absorbance reading truly reflects the concentration of the target element, providing high precision even in samples with complex matrices.

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253. (A) The gradient reorients smoothly parallel to the centrifugal force
Swinging-bucket rotors are preferred for density gradient centrifugation because the buckets swing out to a horizontal position as the rotor spins. This allows the gradient to reorient smoothly parallel to the centrifugal force, preventing the mixing or disruption of the sedimenting bands. This orientation ensures high-resolution separation of sub-cellular components and macromolecules, as the bands remain stable and horizontal during both the acceleration and deceleration phases of the run.

254. (B) Preserve protein-protein interactions and enzymatic activity
Mild non-ionic detergents are used for cell lysis when the goal is to preserve protein-protein interactions and enzymatic activity. Unlike harsh ionic detergents like SDS, which denature proteins, non-ionic detergents solubilize the plasma membrane without disrupting the native folded structures or covalent complexes

238. (B) Destroy any contaminating DNase activity
RNase A is typically boiled before use to destroy any contaminating DNase activity. While RNase A is remarkably heat-stable and will renature upon cooling, most DNase enzymes are irreversibly denatured by boiling. This ensures that the enzyme preparation will specifically degrade only the RNA in a sample, which is essential for protecting the integrity of the target DNA during purification and other sensitive molecular procedures.

239. (B) 40 µg/mL
In UV spectrophotometry, one unit of absorbance at 260 nanometers roughly equals a concentration of forty micrograms per milliliter for single-stranded RNA. This standard conversion factor allows for the rapid quantification of RNA samples after extraction. It is distinct from the factors used for double-stranded DNA, which is fifty, and single-stranded DNA, which is thirty-three. These constants are fundamental for standardized nucleic acid analysis in molecular biology.

240. (B) 3-5°C below the primer T_m
The annealing temperature in PCR is typically set three to five degrees Celsius below the calculated melting temperature of the primers. This ensures that the primers can specifically hybridize to the template DNA without non-specific binding or primer-dimer formation. Selecting the correct annealing temperature is critical for achieving high amplification efficiency and specificity, as temperatures that are too low or too high can lead to sub-optimal results.

241. (B) Viral (bacteriophage) infections
Restriction enzymes naturally protect bacteria from viral infections by cleaving the foreign DNA of invading bacteriophages. These enzymes recognize specific sequences and cut the viral genome, effectively neutralizing the threat. The bacterium protects its own DNA by methylating its recognition sites, preventing the enzymes from cutting itself. This primitive immune system is the source of the restriction enzymes that are now fundamental tools in molecular biology and cloning.

242. (C) 1 base pair
Capillary electrophoresis separates short tandem repeats with an exceptional resolution of one base pair. By pulling the DNA fragments through a narrow tube filled with a polymer matrix, the technique resolves even the smallest differences in fragment length. This precision is essential for DNA profiling and forensic analysis, as it allows for the accurate identification of different alleles at multiple loci, providing unique and reliable genetic fingerprints.

243. (A) Bind DNA covalently and are physically stronger
Nylon membranes are often preferred over nitrocellulose for Southern blotting because they bind DNA covalently and are significantly more durable. Their physical strength allows for multiple rounds of stripping and re-probing, which is valuable for complex genetic analyses. Additionally, nylon membranes have a higher binding capacity for small DNA fragments and do not require the fragile baking steps often necessary with nitrocellulose, making them more versatile in the laboratory.

244. (A) Lambda phages
Cosmids are specialized vectors that combine the features of bacterial plasmids and the cohesive ends of lambda phages. The presence of the "cos" sites allows the recombinant DNA to be packaged into lambda phage heads in vitro, which then efficiently infect bacteria via transduction. This hybrid design enables the cloning of larger DNA inserts than standard plasmids, typically ranging from thirty-five to forty-five kilobases, facilitating genomic library construction.

245. (B) Zero target antigen
In a competitive ELISA, the maximum signal is obtained when the sample contains zero target antigen. Because there is no competition from sample antigens, the fixed amount of labeled antigen can bind freely to all available antibody sites. This results in the highest level of enzyme activity and color development. As the concentration of antigen in the sample increases, the signal decreases, reflecting the inverse relationship inherent in this assay format.

246. (A) Relative transcript abundance between two samples
Two-color DNA microarrays measure the relative transcript abundance between two different biological samples, such as healthy and diseased tissues. Each sample's cDNA is labeled with a distinct fluorophore, and both are hybridized to the same array. The resulting ratio of fluorescence

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density of the medium provides stability and ensures that different components are separated based on their specific physical properties. This stabilization is essential for achieving high-resolution fractionation of sub-cellular organelles and macromolecules during ultracentrifugation, preventing the re-mixing of the separated zones.

279. (A) Potter-Elvehjem
The Potter-Elvehjem homogenizer is a type of mechanical disruptor that forces tissue between a rotating pestle and a stationary glass tube. This action creates liquid shear forces that break open cells while maintaining the structural integrity of delicate organelles like mitochondria. It is a standard tool for the gentle homogenization of animal tissues, such as liver or brain, to isolate functional components for biochemical assays and sub-cellular fractionation studies in molecular biology.

280. (A) Molecular weight and physical size
Ultrafiltration membranes separate molecules primarily based on their molecular weight and physical size. The membrane has a defined molecular weight cut-off that allows smaller molecules and solvents to pass through as permeate while retaining larger macrosolutes. This driving force is typically provided by hydrostatic pressure. This technique is widely used for concentrating protein samples, desalting, and clarifying biological fluids by selecting a membrane with the appropriate pore size for the target analytes.

281. (C) 562 nm
The colorimetric product of the bicinchoninic acid assay is a stable, purple-colored complex that is measured at an absorbance of 562 nanometers. This complex forms when monovalent copper ions, produced by the reduction of Cu^{2+} by proteins in an alkaline medium, react with the BCA reagent. The intensity of the color is directly proportional to the total protein concentration in the sample, providing a highly sensitive and detergent-tolerant method for protein quantification in research.

282. (A) Protect the analytical column from particulate matter and irreversibly bound compounds
In HPLC, guard columns are short pre-columns used to protect the more expensive analytical column from particulate matter and irreversibly bound compounds in the sample. By trapping these contaminants before they reach the main column, the guard column extends the analytical column's lifespan and maintains its performance. This simple preventive measure is essential for ensuring consistent separation results and reducing overall laboratory maintenance costs when analyzing complex biological or environmental samples.

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283. (A) Gradient elution
Temperature programming in gas chromatography is analogous to gradient elution in high-performance liquid chromatography. Both techniques involve changing a critical parameter during the run to improve the separation of complex mixtures. In GC, increasing the temperature lowers the retention of less volatile compounds, while in HPLC, changing the mobile phase composition achieves a similar effect for more strongly retained analytes. This allows for faster analysis and better resolution for wide-boiling or wide-polarity samples.

284. (A) 4-10 atoms
In affinity chromatography, a spacer arm length of four to ten atoms is typically considered optimal to prevent steric hindrance. This distance provides sufficient space between the solid matrix and the ligand, allowing the target protein to bind freely without interference from the support material. Using an appropriately sized spacer arm is crucial for ensuring the high specificity and efficiency of the binding interaction, particularly when the target protein is large or has a recessed binding site.

285. (A) Maximum sensitivity for trace amounts of protein is required
Silver staining is preferred over Coomassie blue when maximum sensitivity for detecting trace amounts of protein is required. Silver staining can detect as little as one nanogram of protein, making it up to one hundred times more sensitive than traditional Coomassie methods. This high sensitivity is essential for identifying low-abundance proteins in complex mixtures or for confirming the purity of samples that appear empty with less sensitive staining techniques in molecular research.

of the proteins. This allows researchers to perform subsequent functional assays or immunoprecipitations on the extracted cellular components while maintaining their biological relevance and active states.

255. (A) High solubility and favorable Hofmeister series ranking
Ammonium sulfate is the most common salt for protein precipitation due to its high solubility in water and its favorable position in the Hofmeister series. It effectively sequesters water molecules, leading to the "salting out" of proteins without causing irreversible denaturation. Its high solubility allows for the achievement of very high ionic strengths, making it a versatile and gentle tool for the initial purification and concentration of many diverse proteins.

256. (D) Glycine
Glycine does not significantly absorb ultraviolet light at 280 nanometers because it lacks the aromatic side chains necessary for this interaction. In contrast, tryptophan and tyrosine have extensive conjugated systems that absorb light strongly at this wavelength. Spectrophotometric protein quantification at 280 nanometers primarily relies on these aromatic residues. Therefore, a protein lacking these amino acids would show minimal absorbance, making this method unsuitable for its detection and quantification.

257. (A) Sample injection and maximum peak detection
Retention time in high-performance liquid chromatography is defined as the time elapsed between the moment of sample injection and the point of maximum peak detection at the detector. This value is characteristic for a given compound under specific experimental conditions, such as the choice of column, mobile phase, and flow rate. It allows researchers to identify analytes by comparing their retention times to those of known reference standards.

258. (A) Trace analysis of very dilute samples
Splitless injection in gas chromatography is used primarily for the trace analysis of very dilute samples. In this mode, the entire sample is introduced onto the column, maximizing the amount of analyte that reaches the detector. This approach provides significantly higher sensitivity compared to split injection, which discards most of the sample. It is essential for detecting environmental contaminants or pharmaceutical residues that are present at extremely low concentrations in complex biological matrices.

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259. (A) The 150 kDa protein
A protein of 150 kilodaltons will elute first from a Sephadex G-100 column because its size exceeds the exclusion limit of the gel matrix. Consequently, it cannot enter the pores of the beads and travels quickly through the void volume. The 50 kilodalton protein is small enough to enter the pores, which increases its travel path and delays its elution. This size-based separation is a fundamental principle of gel filtration chromatography.

260. (A) Lower acrylamide concentration and lower pH than the resolving gel
The stacking gel in SDS-PAGE is characterized by a lower acrylamide concentration and a lower pH compared to the resolving gel. These conditions are designed to concentrate the proteins into a very thin, sharp band before they enter the resolving gel for separation. This "stacking" effect ensures that all proteins of the same size start their separation at the same time, significantly improving the resolution and clarity of the final bands.

261. (A) Amino acid substitution that changes the net charge
Isoelectric focusing is highly effective for separating protein variants that differ by even a single amino acid substitution, provided the change alters the net charge of the molecule. Because separation is based on the isoelectric point, any modification that changes the protein's overall charge will shift its final position in the pH gradient. This makes IEF a powerful tool for studying protein isoforms, post-translational modifications, and genetic polymorphisms in various biological research and clinical diagnostic applications.

262. (A) Radioactive isotopes within a sample
Autoradiography involves exposing X-ray film or a phosphor imaging plate to detect the distribution of radioactive isotopes within a sample. The radiation emitted by the labeled molecules reacts with the photographic emulsion, creating a visible image after development. This technique is widely used to visualize the results of Northern and Southern blotting, as well as to

track the location of radioactive tracers in tissues and cells during metabolic and genomic studies.

263. (A) Upper aqueous phase
During phenol-chloroform extraction, DNA partitions into the upper aqueous phase. This occurs because DNA is highly polar and hydrophilic, making it more soluble in water than in the organic solvents. Proteins, being denatured by the phenol, are sequestered into the organic layer or accumulate at the interface. This clear separation allows researchers to easily collect the purified nucleic acids from the top layer for subsequent recovery and use in various molecular experiments.

264. (A) Salts or organic solvents
An $\frac{A_{260}}{A_{230}}$ ratio of 0.8 typically indicates significant contamination of a nucleic acid sample with salts, carbohydrates, or organic solvents used during extraction. These contaminants absorb light strongly at 230 nanometers, causing the ratio to drop well below the ideal value of 2.0. Monitoring this ratio is essential for evaluating sample quality, as these substances can inhibit downstream enzymatic reactions and interfere with the accuracy of PCR, sequencing, and other sensitive applications.

265. (A) Non-specific amplification at low temperatures during reaction setup
Hot-start PCR utilizes a modified Taq polymerase that is inactive at room temperature, preventing non-specific amplification and primer-dimer formation during reaction setup. The enzyme is activated only after the initial high-temperature denaturation step. This approach significantly improves the specificity and yield of the target product, making it particularly valuable when working with complex templates or when high precision is required in diagnostic and research molecular biology laboratory procedures.

266. (A) Large amounts of intact, high-molecular-weight DNA
RFLP analysis has been largely superseded in forensics because it requires large amounts of relatively intact, high-molecular-weight DNA. This was often difficult to obtain from crime scene samples, which are frequently minute or degraded. In contrast, PCR-based methods can amplify and analyze very small or damaged DNA fragments, making them far more versatile and practical for modern forensic identification and genetic analysis across all fields of biological and clinical sciences.

267. (A) Replication slippage during DNA synthesis
STR loci are highly polymorphic primarily due to replication slippage during DNA synthesis. As DNA polymerase duplicates these repetitive sequences, it can occasionally "slip," leading to the addition or deletion of repeat units in the new strand. This mechanism creates a high rate of mutation in the number of repeats, resulting in the many different allele sizes observed in a population. This variability is what makes microsatellites such powerful markers for individual identification and parentage testing.

268. (A) Complementary to the target sequence and labeled for detection
A Southern blot probe must be complementary to the specific target DNA sequence and labeled with a radioactive or fluorescent tag for detection. This allows the probe to hybridize specifically to the target fragment immobilized on the membrane. By utilizing these specific base-pairing interactions, researchers can identify the presence and size of particular genomic fragments among millions of others, facilitating genetic mapping, forensic identification, and the diagnosis of hereditary diseases in various animal species.

269. (A) E. coli F-factor plasmid
BAC vectors are based on the E. coli F-factor plasmid, which is naturally maintained at a very low copy number within the bacterial host. This low copy number is essential for the stability of large DNA inserts, as it minimizes the risk of recombination and rearrangement. This characteristic allows BACs to carry and replicate fragments up to three hundred kilobases, making them indispensable tools for genome mapping, genomic library construction, and large-scale genetic studies.

270. (A) There is no signal amplification from secondary antibodies
Direct ELISA is generally less sensitive than indirect ELISA because it lacks the signal amplification provided by secondary antibodies. In a direct ELISA, the primary antibody is directly conjugated to the enzyme. In an indirect ELISA, multiple secondary antibodies can bind to a single primary antibody, significantly increasing the total amount of enzyme activity

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and color development for each target molecule. This makes the indirect format preferred for detecting low concentrations of analytes in samples.

271. (A) Global mRNA expression levels
Microarrays analyze the transcriptome by simultaneously measuring the global expression levels of thousands of mRNA transcripts. By hybridizing labeled cDNA from a sample to an array of specific DNA probes, researchers can determine which genes are being transcribed and at what intensity. This provides a comprehensive "snapshot" of cellular activity, allowing for the comparison of gene expression between different biological states, tissues, or treatments, which is fundamental to modern genomics and systems biology research.

272. (A) Resistance to photobleaching and broad excitation spectra
Quantum dots offer significant advantages over traditional organic fluorophores due to their exceptional resistance to photobleaching and their broad excitation spectra. Unlike organic dyes, which lose their signal quickly under light, quantum dots can be monitored for long periods without fading. Furthermore, multiple colors can be excited by a single light source, making them ideal for multiplex imaging and the long-term tracking of specific molecules or cells in complex biological systems and diagnostic assays.

273. (A) Skeletal or cardiac muscle injury
An increase in serum aspartate aminotransferase without a corresponding increase in alanine aminotransferase strongly suggests skeletal or cardiac muscle injury. While AST is found in both liver and muscle, ALT is primarily liver-specific in dogs and cats. Therefore, an isolated AST elevation indicates that the source of the enzyme is likely muscle tissue. This distinction is critical in clinical veterinary medicine for accurately identifying the organ system affected by injury or disease during laboratory evaluations.

274. (A) Pre-renal azotemia
In a dehydrated animal, blood urea nitrogen increases while serum creatinine often remains relatively normal initially, a condition called pre-renal azotemia. This occurs because dehydration leads to reduced renal blood flow and increased urea reabsorption, while creatinine excretion is less immediately affected. This clinical finding is essential for distinguishing between primary kidney disease and external factors that compromise renal perfusion, such as dehydration, hemorrhage, or heart failure, allowing for appropriate treatment strategies.

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275. (A) Average blood glucose concentrations over the previous 1-3 weeks
Measuring serum fructosamine is preferred for monitoring diabetes in animals because it reflects the average blood glucose concentration over the previous one to three weeks. Unlike a single glucose reading, which can be highly variable due to stress or food intake, fructosamine provides a more stable and reliable measure of long-term glycemic control. This allows veterinarians to assess the effectiveness of insulin therapy and make necessary adjustments based on a broader metabolic picture of the patient.

276. (C) 1.0 to 1.5
The linear range of the Beer-Lambert law typically fails at absorbances above 1.0 to 1.5. At these high values, the amount of light reaching the detector is so low that stray light and electronic noise become significant sources of error. Additionally, chemical deviations due to high solute concentrations can alter the relationship between concentration and absorbance. To ensure accuracy, samples with high absorbance should be diluted until they fall within the reliable linear range.

277. (A) Alkali and alkaline earth metals (Na, K, Ca, Li)
Flame emission photometry is most suitable for detecting alkali and alkaline earth metals such as sodium, potassium, calcium, and lithium. These elements have relatively low excitation energies and produce characteristic vibrant emission lines when introduced into a flame. This property makes the technique exceptionally valuable in clinical laboratories for the rapid and accurate measurement of electrolyte concentrations in biological fluids like serum and urine, facilitating the diagnosis of various metabolic imbalances.

278. (A) Convection currents and stabilize the sedimenting bands
Density gradient centrifugation utilize a medium like sucrose or cesium chloride to create a density gradient that prevents convection currents and stabilizes the sedimenting bands. As particles move through the gradient, the increasing

while keeping delicate organelles like nuclei and mitochondria intact. It is a preferred method for isolating functional sub-cellular components for biochemical study.

230. (B) Increased hydrophobic interactions
Salting out proteins at high salt concentrations relies on increased hydrophobic interactions. As salt ions sequester water molecules away from the protein's surface, the protective hydration shell is disrupted. This exposes hydrophobic patches on the proteins, causing them to associate and aggregate. This process leads to the precipitation of the proteins from the solution, allowing for their concentrated recovery in a stable and often reversible manner.

231. (B) Reducing agents like DTT and mercaptoethanol
The Lowry assay is highly sensitive to interference from reducing agents, such as dithiothreitol and beta-mercaptoethanol. These substances can prematurely reduce the Folin-Ciocalteu reagent, leading to false-positive results and inaccurately high absorbance readings. When working with protein samples containing these common laboratory reagents, alternative quantification methods like the Biuret or BCA assays are typically used to ensure accurate and reliable measurements.

232. (A) Negatively charged groups (e.g., CM)
Cation-exchange resins contain negatively charged functional groups, such as carboxymethyl, that specifically bind to positively charged molecules in a mixture. At a pH below their isoelectric point, proteins carry a net positive charge and will interact with these acidic groups. By gradually increasing the salt concentration or altering the pH, the bound proteins can be selectively eluted based on their individual charge densities and binding strengths.

233. (B) Wall-coated open tubular (WCOT) capillary column
A wall-coated open tubular capillary column is characterized by a very small internal diameter and high resolution in gas chromatography. Unlike packed columns, the stationary phase is coated directly on the inner wall of the fused-silica tube. This open structure allows for longer column lengths and superior separation efficiency, making it the preferred choice for the detailed analysis of complex volatile mixtures in research and forensics.

234. (D) Solid support matrix
In affinity chromatography, the biospecific ligand is covalently attached to a solid support matrix, such as agarose or polyacrylamide beads. This immobilized ligand specifically captures the target protein from a complex mixture as it passes through the column. Once non-binding contaminants are washed away, the target protein is eluted by introducing a competing ligand or changing the buffer conditions, resulting in high-purity protein isolation.

235. (A) APS and TEMED
Acrylamide gels are polymerized through a free-radical reaction initiated by ammonium persulfate and catalyzed by TEMED. APS provides the initial free radicals, while TEMED accelerates the polymerization process by stabilizing these radicals. Together, they cause the acrylamide and bis-acrylamide monomers to cross-link, forming a stable porous matrix used for the electrophoretic separation of proteins and nucleic acids in various molecular biology laboratory settings.

236. (C) Zero net charge
The isoelectric point of a protein is the specific pH at which it carries a zero net electrical charge. At this pH, the number of positive charges on the protein's surface exactly equals the number of negative charges. Consequently, the protein will not migrate in an electric field. This fundamental property is exploited in isoelectric focusing to separate complex protein mixtures with exceptional resolution based on their individual pI values.

237. (A) Geiger-Müller region
Geiger-Müller counters operate within the Geiger-Müller region of the gas ionization curve. In this region, a high voltage is applied across the tube, ensuring that any ionization event triggers a complete gas discharge across the entire length of the anode. This produces a large, uniform electrical pulse for every detected particle, providing high sensitivity for measuring radioactivity regardless of the type or energy of the radiation.

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286. (A) Often precipitate during the isoelectric focusing step
Two-dimensional gel electrophoresis resolution is often limited for highly hydrophobic membrane proteins because they frequently precipitate during the isoelectric focusing step. These proteins are difficult to maintain in a solubilized state in the absence of detergents, and the standard urea-based buffers used in IEF may not be sufficient to keep them from aggregating as they reach their isoelectric point. This makes the analysis of membrane proteomes more challenging compared to soluble cytosolic proteins.

287. (A) Photomultiplier tube (PMT)
The photomultiplier tube is the component in a liquid scintillation counter that converts the light flash from a scintillator into an amplified electrical pulse. When light photons strike the tube's photocatode, they release electrons, which are then multiplied through a series of dynodes. This process generates a detectable signal that is proportional to the number of photons, allowing for the sensitive and accurate quantification of radioactivity in a wide range of biological and chemical samples.

288. (A) Vigorous vortexing
To prevent DNA shearing during genomic DNA extraction, one must strictly avoid vigorous vortexing of the sample. Long genomic DNA molecules are highly susceptible to mechanical shear forces, which can break the long strands into much smaller fragments. Instead, gentle mixing by inversion is recommended to maintain the high molecular weight of the DNA. Preserving DNA integrity is essential for successful long-range PCR, Southern blotting, and high-quality genomic library construction in various molecular research applications.

289. (A) Are ubiquitous, highly stable enzymes that do not require metal cofactors
Extracted RNA is highly susceptible to degradation because RNases are ubiquitous and exceptionally stable enzymes. Unlike many other enzymes, RNases do not require metal cofactors for their activity and can survive extreme conditions like boiling or acidic pH. Their presence on human skin and lab surfaces makes contamination a constant risk. Consequently, maintaining a strictly RNase-free environment through the use of specific inhibitors and treated water is essential for successful RNA work.

290. (A) Amplifying highly conserved regions where the exact codon usage is unknown
Degenerate primers in PCR are used to amplify highly conserved regions where the exact codon usage is unknown or varies between species. These primers consist of a mixture of oligonucleotides representing multiple possible sequences at specific positions. This approach allows for the discovery of novel genes in different organisms or the amplification of members of a multi-gene family by targeting their shared functional domains, expanding the reach of the basic PCR technique in genomics and evolution.

291. (A) A palindromic sequence like GAATTC
A common recognition site for a Type II restriction endonuclease is a short, palindromic sequence of four to eight base pairs, such as GAATTC for EcoRI. These sequences read the same in the five-prime to three-prime direction on both strands. The enzyme binds to this symmetry and cleaves the DNA at specific positions within or near the site, producing predictable fragments with either sticky or blunt ends. This sequence specificity is the basis for most molecular cloning and genetic mapping.

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292. (A) Distinguish different loci that may have overlapping size ranges
Multiplex STR analysis utilizes fluorescently labeled primers to distinguish different loci that may have overlapping size ranges during separation. By using multiple different-colored fluorophores, several STR markers can be analyzed simultaneously on a single capillary electrophoresis run. This "color-coding" allows for the high-throughput generation of complex genetic profiles, making individual identification and parentage testing significantly more efficient and reliable than single-locus analysis, providing unique and highly discriminative genetic fingerprints for research and forensics.

293. (A) Disrupting hydrogen bonds between base pairs
Formamide decreases the melting temperature of DNA hybrids by disrupting the hydrogen bonds between complementary base pairs. By stabilizing the single-stranded state of the DNA, it allows for specific hybridization to occur at lower experimental temperatures than would

otherwise be required. This is particularly useful in Southern and Northern blotting to maintain probe specificity while preventing the thermal degradation of the target molecules or the membrane, ensuring clearer and more accurate detection of specific nucleic acid sequences.

294. (A) Plasmids and filamentous phages like M13
Phagemids are hybrid vectors that combine features of bacterial plasmids and the replication origin of filamentous phages like M13. They function like standard plasmids for cloning but can be induced to produce single-stranded DNA when the host is infected with a helper phage. This versatility makes them excellent tools for DNA sequencing, site-directed mutagenesis, and the construction of phage display libraries, offering a powerful platform for various advanced molecular biology and protein engineering applications.

295. (A) Bound radioactivity versus known concentrations of unlabeled antigen
In a radioimmunoassay, the standard curve is typically plotted by graphing the percentage of bound radioactivity against the known concentrations of the unlabeled antigen. This curve shows an inverse relationship: as the concentration of unlabeled antigen increases, the amount of bound labeled antigen decreases. This reference curve is then used to determine the concentration of the analyte in unknown samples by measuring their radioactivity, providing a sensitive and quantitative assessment of various biological molecules.

296. (A) Digesting proteins into peptides before mass spectrometry analysis
A bottom-up approach in proteomics refers to the process of digesting proteins into smaller peptides, typically using trypsin, before they are analyzed by mass spectrometry. This method is the most common way to identify proteins in complex mixtures because peptides are easier to separate and ionize than whole proteins. By sequencing these peptides and matching them to databases, researchers can accurately identify the original proteins and assess their expression levels and modifications.

297. (A) Magnetic Resonance Imaging (MRI)
Superparamagnetic iron oxide nanoparticles are heavily researched for use as contrast agents in magnetic resonance imaging. Due to their unique magnetic properties, SPIONs significantly alter the relaxation times of nearby water protons, enhancing the contrast of tissues where they accumulate. They can be functionalized with specific ligands to target tumors or inflammation, providing a powerful platform for sensitive and molecularly specific imaging in both research and clinical veterinary medicine to improve disease diagnosis.

298. (A) Acute pancreatitis
Elevated levels of serum amylase and lipase in a dog with acute abdominal pain and vomiting strongly point toward acute pancreatitis. These enzymes are produced by the pancreas and released into the blood in large quantities when the organ is inflamed or damaged. While other conditions can cause mild elevations, significant increases in these markers, combined with clinical signs, are diagnostic hallmarks used by veterinarians to identify and manage this serious gastrointestinal emergency.

299. (A) It measures only the biologically active unbound hormone, avoiding interference from binding proteins
Free thyroxine measurement by equilibrium dialysis is superior to total thyroxine measurement because it specifically measures only the biologically active, unbound fraction of the hormone. This avoid errors caused by variations in thyroid-binding proteins, which can be influenced by other illnesses or medications. This makes the free T_4 assay a more accurate and reliable diagnostic tool for identifying hyperthyroidism or hypothyroidism in cats and dogs, especially when total T_4 results are borderline or conflicting.

300. (A) I and II
Diagnostic protocols for endocrine disorders involve specific stimulation or suppression tests to evaluate hormonal axes. The thyrotropin-releasing hormone test assesses thyroid function, while the adrenocorticotropic hormone stimulation test confirms hypoadrenocorticism. Feline hyperthyroidism typically results in suppressed thyroid-stimulating hormone levels, meaning the assessment of high levels is generally inaccurate when identifying this specific feline metabolic condition, whereas the other mentioned stimulation tests are correctly identified in their respective clinical diagnostic contexts.

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CHAPTER 10
Bioinformatics

NODIA

2006

1. Which fundamental process of the central dogma describes the synthesis of an RNA molecule from a DNA template?
(A) Reverse transcription
(B) Transcription
(C) Translation
(D) Replication

2014

2. How are primary biological databases formally distinguished from secondary databases in bioinformatics?
(A) Primary databases house derived motifs, whereas secondary ones store raw experimental data points
(B) Primary databases contain exclusively structural coordinates, whereas secondary databases contain sequences
(C) Primary databases are manually curated, whereas secondary databases are completely automated platforms
(D) Primary databases contain experimental sequence data, whereas secondary ones contain derived motifs and profiles

2018

3. Which of the following is NOT a member of the International Nucleotide Sequence Database Collaboration (INSDC)?
(A) Protein Information Resource (PIR)
(B) GenBank
(C) DNA Data Bank of Japan (DDBJ)
(D) European Nucleotide Archive (ENA/EMBL)

2018

4. In the context of protein databases, what is the primary difference between SWISS-PROT and TrEMBL?
(A) SWISS-PROT stores nucleotide sequences, while TrEMBL stores protein sequences for database mining
(B) SWISS-PROT is exclusive to eukaryotic proteins, while TrEMBL is for prokaryotic protein sequences
(C) SWISS-PROT is manually annotated and reviewed, while TrEMBL is computer-annotated and unreviewed
(D) SWISS-PROT utilizes dynamic programming, while TrEMBL utilizes heuristic searches for alignments

2018

5. The Protein Data Bank (PDB) utilizes specific coordinate formats for macromolecular structures. Which statement accurately describes a standard PDB file format?
(A) It stores spatial coordinates of atoms along with HEADER, ATOM, and HETATM records
(B) It contains only the atomic coordinates without associated metadata or experimental details
(C) It exclusively utilizes binary formats to compress sequence data
(D) It aligns protein sequences prior to structural modeling

2011

6. The Entrez system developed by NCBI primarily functions as which of the following?
(A) A comprehensive sequence alignment algorithm for global comparisons
(B) A molecular docking simulation tool for drug discovery
(C) A phylogenetic tree construction program based on distance
(D) An integrated information retrieval system for interconnected databases

2025

7. Which term describes homologous genes found in different species that evolved from a common ancestral gene via speciation?
(A) Paralogs
(B) Orthologs
(C) Xenologs
(D) Analogs

2004

8. In sequence alignment scoring schemes, why is an affine gap penalty typically preferred over a linear gap penalty?
(A) It applies identical penalties to gap opening

conformational changes in the ligand
(D) Search algorithms explore the conformational space to find the minimal energy binding pose

2009

59. In 2D QSAR methodology, which statistical technique is most commonly employed to model the relationship between physicochemical descriptors and biological activity?
(A) Dynamic Programming
(B) Multiple Linear Regression (MLR)
(C) Fast Fourier Transform
(D) Maximum Parsimony

2012

60. What is the correct chronological sequence of steps in a standard structure-based molecular docking workflow?
1. Scoring and ranking of predicted poses
2. Preparation of target receptor (adding hydrogens, assigning charges)
3. Selection of binding pocket/grid generation
4. Conformational search of the ligand within the pocket

(A) 2, 3, 4, 1
(B) 3, 2, 4, 1
(C) 2, 4, 3, 1
(D) 4, 2, 3, 1

2007

61. Which structural database formally categorizes protein structures based on evolutionary and structural relationships using Class, Architecture, Topology, and Homologous superfamily classifications?
(A) CATH
(B) SCOP
(C) PROSITE
(D) PDBsum

2016

62. Which database retrieval system acts as the primary European counterpart to NCBI's Entrez system?
(A) DDBJ
(B) RCSB
(C) SRS (Sequence Retrieval System)
(D) UniProtKB

2021

63. A local alignment between two sequences is biologically more relevant than a global alignment when the sequences:
(A) Are identical in length and highly conserved throughout the entire sequence comparison
(B) Belong to the exact same species and are from identical genomic loci across individuals
(C) Consist purely of repetitive non-coding DNA segments found throughout the chromosomes
(D) Share only a short conserved domain but are otherwise highly divergent from each other

2021

64. Identify the correct statement regarding the FASTA format.
(A) It relies entirely on binary encoding for nucleotide sequences
(B) It requires a continuous string of sequences with no headers permitted
(C) It begins with a greater-than symbol (>) followed by a description line, with sequence data on subsequent lines
(D) It exclusively supports protein sequences

2010

65. Consider the following statements about scoring matrices:
I. PAM matrices assume a Markov model of protein evolution.
II. BLOSUM62 is derived from alignments with a maximum of 62% identity.
III. PAM250 represents an evolutionary distance of 250 mutations per 100 amino acids.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2002

66. If an E-value of a BLAST search result is exactly 0.0, what does this mathematically infer regarding the alignment?
(A) The alignment is entirely random and statistically insignificant
(B) The sequence contains zero gap penalties
(C) The query sequence is absent from the database
(D) The match is virtually identical, and the probability of it occurring by chance is practically zero

2007

67. Progressive alignment tools like ClustalW suffer from which major algorithmic limitation?
(A) Errors made in the early stages of alignment are propagated and cannot be corrected later
(B) They cannot process more than three sequences simultaneously

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2010

17. Which of the following phylogenetic tree construction methods is characterized as a character-based rather than a distance-based method?
(A) UPGMA
(B) Maximum Parsimony
(C) Neighbor-Joining (NJ)
(D) Minimum Evolution

2025

18. During the processing of Expressed Sequence Tags (ESTs) in transcriptomics, what is the primary purpose of EST clustering?
(A) To randomly assemble disjointed genomes using a variety of different sequencing platforms and technologies
(B) To separate cDNA sequences from mRNA sequences to ensure that the final library is free of contamination
(C) To map strictly intronic regions of the genome that are not represented in the final protein translation
(D) To group redundant overlapping ESTs into continuous unique contiguous sequences known as consensus contigs

2025

19. Under the GNU General Public License (GPL) ecosystem, which condition applies to derivative works of open-source bioinformatics software?
(A) They must be distributed under identical open-source license terms
(B) They can be strictly closed-source upon modification
(C) They must be approved by the original author before internal use
(D) They require mandatory commercial licensing fees

2013

20. Match the CADD approaches (List I) with their corresponding definitions (List II):
List I: (CADD Approaches)
P. Ligand-based drug design
Q. Structure-based drug design
R. Pharmacophore modeling
S. Molecular docking
List II: (Definitions)
1. Relies on the 3D structure of the biological target
2. Predicting optimal binding orientation and affinity
3. Defining the minimum steric and electronic features necessary for interaction
4. Relies on knowledge of known active small molecules
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-4, S-2

2007

21. Which thermodynamic scoring function component accounts for the expulsion of water molecules from a hydrophobic binding pocket during molecular docking?
(A) Solvation/desolvation entropy
(B) Electrostatic interactions
(C) Hydrogen bonding penalties
(D) Covalent bond deformation

2024

2024

22. In Quantitative Structure-Activity Relationship (QSAR) models, the partition coefficient ($LogP$) is primarily utilized to estimate which physicochemical property?
(A) Molecular polarizability
(B) Topological branching
(C) Molar refractivity
(D) Lipophilicity/hydrophobicity

2008

23. Comparative Molecular Field Analysis (CoMFA), a 3D QSAR technique, characterizes ligand sets using which two primary interaction fields?
(A) Hydrogen bond donor and acceptor fields
(B) Steric and electrostatic fields
(C) Hydrophobic and dispersive fields
(D) Covalent and non-covalent fields

2024

24. Which machine learning technique constructs an ensemble of decision trees to enhance predictive QSAR modeling and reduce overfitting?
(A) Support Vector Machines (SVM)
(B) Artificial Neural Networks (ANN)
(C) Random Forests
(D) K-Nearest Neighbors (KNN)

2025

25. Consider the following statements regarding biological databases:
I. Primary databases archive direct experimental submissions.
II. Composite databases merge data from multiple primary sources.
III. Secondary databases provide curated motifs and evolutionary relationships.

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and extension, which simplifies the overall calculation process
(B) It penalizes gap extension more severely than gap opening, reflecting a specific mathematical sequence model
(C) It reflects the reality that a single mutational event can insert or delete a block of multiple residues
(D) It prevents any gaps from being introduced into the final alignment regardless of the scoring matrix used

2004

9. The PAM (Point Accepted Mutation) matrices are derived from alignments of closely related proteins. Which matrix is most appropriate for comparing highly divergent sequences?
(A) PAM1
(B) PAM30
(C) PAM10
(D) PAM250

2002

10. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): The dot matrix method is highly effective for visually identifying direct and inverted repeats within a single sequence.
Reason (R): In a self-alignment dot plot, parallel diagonals offset from the main diagonal indicate repeated sequence segments.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

11. Which algorithmic approach is utilized by the Needleman-Wunsch algorithm for sequence alignment?
(A) Hidden Markov Models
(B) Global dynamic programming
(C) Local dynamic programming
(D) Heuristic word searching

2007

12. In the FASTA heuristic algorithm, what does the E-value (Expectation value) signify?
(A) The exact percentage of identical residues between two sequences compared in the alignment
(B) The number of alignments with a given score expected to occur by chance in a database search
(C) The number of distinct gap openings required to reach the optimal score in a pairwise alignment
(D) The statistical length of the query sequence mapped to the entire searchable protein database

2018

13. Which BLAST program specifically designed to translate a nucleotide query into all six reading frames and compare it against a protein sequence database?
(A) blastx
(B) blastn
(C) blastp
(D) tblastn

2002

14. Which multiple sequence alignment approach mitigates the "once a gap, always a gap" problem by repeatedly realigning subgroups of sequences?
(A) Strict progressive alignment
(B) Dot-matrix self-alignment
(C) Iterative alignment
(D) Exact dynamic programming

2005

15. Consider the following statements regarding ClustalW:
I. It generates a guide tree using a distance matrix to direct the alignment.
II. It guarantees the mathematically optimal global alignment for all input sequences.
III. It is a progressive multiple sequence alignment tool.
Which of the above statement(s) is/are correct?
(A) I and III
(B) I and III
(C) II and III
(D) II only

NODIA

2015

16. In the context of molecular phylogeny, a clade is defined as which of the following?
(A) An isolated node representing an extinct taxonomic unit
(B) A graphical representation of horizontal gene transfer
(C) A group of organisms consisting of a single common ancestor and all its descendants
(D) The specific branch length corresponding to mutation rate

without restriction

2021

34. What is the fundamental distinction between a cDNA library and a genomic DNA library?
(A) A cDNA library contains both introns and exons, whereas a genomic library contains only transcribed exons
(B) A cDNA library requires restriction enzyme digestion of the entire genome using specific molecular tools
(C) A genomic library is reverse-transcribed from purified mRNA extracted from specific specialized cell types
(D) A cDNA library represents only transcribed genes of a cell type, lacking introns and regulatory regions

2017

35. Consider the following statements about CADD and QSAR:
I. Molecular docking predicts ligand conformation within a receptor site.
II. 3D QSAR requires superimposition of ligand structures.
III. *LogP* is a geometric descriptor.
IV. CoMSIA calculates hydrophobic and hydrogen-bonding fields.
V. SVM is purely a linear regression tool and cannot model non-linear data.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, III, IV and V
(C) II, III and V
(D) I, IV and V

2024

36. Which scoring function category in molecular docking relies on empirical datasets of known receptor-ligand complexes to determine binding affinity contributions?
(A) Force field-based scoring functions
(B) Knowledge-based scoring functions
(C) Empirical scoring functions
(D) Quantum mechanical scoring functions

2011

37. In the context of 3D QSAR, how does CoMSIA generally improve upon the traditional CoMFA methodology?
(A) By utilizing a distance-dependent Gaussian function to avoid singularities at atomic centers
(B) By completely disregarding electrostatic interactions
(C) By replacing molecular superimposition with topological 2D descriptors
(D) By strictly limiting calculations to steric fields

2025

38. Identify the INCORRECT statement regarding the application of Artificial Neural Networks (ANN) in QSAR modeling.
(A) ANNs can efficiently model complex, non-linear relationships between descriptors and biological activity
(B) ANNs consist of input, hidden, and output layers of interconnected nodes
(C) Backpropagation is a common training algorithm used to adjust synaptic weights
(D) ANNs are highly resistant to overfitting, eliminating the need for validation datasets

2007

39. Which biological database strictly acts as a primary repository for experimentally determined protein sequences?
(A) PROSITE
(B) PIR
(C) Pfam
(D) PRINTS

2019

40. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): The Needleman-Wunsch algorithm is suboptimal for identifying a short conserved domain within two highly divergent, unequal-length protein sequences.
Reason (R): Global alignment algorithms force the entire length of both sequences to align, penalizing unaligned end regions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

41. Which principle explicitly defines an orthologous gene relationship?
(A) Gene duplication within the same lineage
(B) Convergent evolution of distinct genes towards a common function
(C) Viral-mediated lateral gene transfer
(D) Speciation leading to functional divergence

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(B) To strictly archive raw sequencing reads from agricultural crops
(C) To replace the INSDC collaboration entirely
(D) To model the 3D structures of agricultural pests

2003

77. Which statement correctly differentiates orthologs from paralogs?
(A) Orthologs arise via speciation and typically retain similar function, while paralogs arise via gene duplication and often evolve new functions
(B) Paralogs arise via speciation, while orthologs arise via gene duplication
(C) Orthologs are strictly found within the exact same genome
(D) Paralogs are always horizontally transferred between unrelated species

2023

78. When scoring an alignment, an affine gap penalty is calculated using the formula $Penalty = GO + (GE \times L)$. What do GO, GE, and L represent?
(A) Gap Overall, Gap Exact, Length
(B) General Offset, Global Extension, Limit
(C) Gap Opening, Gap Extension, Length of the gap
(D) Gap Optimization, Gap Evaluation, Length

2012

79. Which dot matrix filtering technique removes background noise by requiring a minimum number of matches within a specified window size?
(A) Dynamic programming filtration
(B) E-value cutoff
(C) Affine gap scaling
(D) Stringency/Windowing threshold

2025

80. Which of the following represents the correct progression of steps involved in a general QSAR modeling study?
1. Model validation (internal and external)
2. Selection of biological activity data
3. Calculation of molecular descriptors
4. Statistical modeling and regression

(A) 2, 3, 4, 1
(B) 3, 2, 4, 1
(C) 2, 4, 3, 1
(D) 3, 4, 2, 1

NODIA

2002

81. In the Needleman-Wunsch algorithm, initialization of the first row and column of the scoring matrix is determined by:
(A) Multiplying the mismatch scores
(B) The cumulative gap penalty for alignments with empty sequences
(C) Assigning zero to all cells
(D) The maximum BLOSUM62 score

2001

82. Which heuristic method utilizes a "k-tuple" or word-based approach to rapidly identify initial regions of similarity before performing full dynamic programming alignments?
(A) Maximum Parsimony
(B) Needleman-Wunsch
(C) UPGMA
(D) FASTA

2001

83. Why is the tblastx algorithm computationally expensive and generally slower than blastn?
(A) It translates both nucleotide sequences into all six reading frames, requiring 36 distinct pairwise comparisons
(B) It performs rigid-body molecular docking on the fly
(C) It calculates the full global alignment matrix for the entire genome
(D) It restricts the search to only the primary reading frame

2004

84. Which statement correctly identifies an advantage of iterative multiple sequence alignment methods (e.g., MUSCLE) over standard progressive methods (e.g., ClustalW)?
(A) Iterative methods are strictly limited to two sequences
(B) Iterative methods completely eliminate the need for scoring matrices
(C) Iterative methods refine initial alignments through repeated realignment passes, correcting early errors
(D) Iterative methods ignore evolutionary distances

2021

85. Consider the following statements about phylogeny:
I. Distance-based methods compute a pairwise distance matrix before tree construction.
II. UPGMA assumes equal evolutionary rates among all lineages.
III. Maximum Parsimony is a distance-based

(D) To model atomic force fields for thermodynamic scoring

2016

50. Match the sequence alignment concepts (List I) with their definitions (List II):
List I: (Sequence Alignment Concepts)
P. Identity
Q. Similarity
R. Homology
S. Gap penalty
List II: (Definitions)
1. Reduction in alignment score due to insertions/deletions
2. The percentage of exact matching residues
3. Evolutionary relatedness due to a common ancestor
4. The degree of resemblance incorporating chemically equivalent residues
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

2001

51. Which database serves as the primary repository for 3D structural data of large biological molecules, such as proteins and nucleic acids?
(A) PDB
(B) EMBL
(C) DDBJ
(D) TrEMBL

2022

52. When analyzing structural coordinates of a protein, which file format utilizes a highly structured, machine-readable text format with specific columns assigned to atom types, coordinates, and occupancy?
(A) FASTA format
(B) FASTQ format
(C) PDB format
(D) GFF format

2021

53. Which term refers to the structural units within a phylogenetic tree where a single ancestral lineage splits into two distinct descendant lineages?
(A) Nodes
(B) Clades
(C) Leaves
(D) Operational Taxonomic Units (OTUs)

2004

54. Why are distance-based methods like Neighbor-Joining (NJ) frequently chosen over Maximum Parsimony for very large phylogenetic datasets?
(A) NJ guarantees the absolute true evolutionary history
(B) NJ evaluates all possible tree topologies exhaustively
(C) NJ requires no underlying multiple sequence alignment
(D) NJ is computationally much faster and efficiently handles large numbers of taxa

2001

55. What specific bioinformatic task is the primary application of the dbEST division of GenBank?
(A) Storing complete annotated whole genomes
(B) Housing collections of short, single-pass sequence reads from mRNA transcripts
(C) Providing highly curated 3D protein coordinate data
(D) Archiving quantitative mass spectrometry data

2013

56. Which computational paradigm dictates that an open-source software license strictly guarantees users the freedom to run, study, share, and modify the software?
(A) Proprietary Licensing
(B) Trade Secret Law
(C) Free and Open-Source Software (FOSS)
(D) Commercial Non-Disclosure Agreements

2001

57. In structure-based drug design, what prerequisite information is absolutely necessary before initiating the computational screening process?
(A) The synthesis pathways of all potential ligands
(B) A large dataset of highly active known inhibitors
(C) The complete genome sequence of the host organism
(D) The 3D high-resolution structure of the biological target receptor

2013

58. Identify the INCORRECT statement concerning molecular docking algorithms.
(A) Induced-fit docking allows strictly the ligand to flex while keeping the receptor rigidly fixed
(B) Rigid docking treats both the ligand and the receptor as inflexible entities
(C) Flexible docking algorithms permit

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or conservation in separate lineages

2006

42. In gap penalty models, what biological phenomenon justifies setting a lower penalty for gap extension than for gap opening?
(A) Polymerase slippage or unequal crossing over often inserts or deletes multiple adjacent residues in a single event
(B) Single point mutations are more common than insertions
(C) Amino acid substitutions occur strictly one residue at a time
(D) Frameshift mutations are completely harmless

2002

43. Which of the following best explains why the BLOSUM62 matrix is the default for most BLASTp searches?
(A) It perfectly identifies short nucleotide motifs
(B) It balances the detection of closely related and moderately distant homologous proteins empirically
(C) It relies on an extrapolated evolutionary model rather than observed data
(D) It lacks gap penalties, speeding up computation

2007

44. What visible pattern on a dot matrix plot unequivocally indicates a tandem repeat within a queried sequence?
(A) A single continuous unbroken diagonal line from corner to corner
(B) Shorter parallel diagonal lines running adjacent to the main central diagonal
(C) Intersecting perpendicular lines forming a cross
(D) Complete scattering of dots with no discernible diagonal

2011

45. Consider the following statements about BLAST variants:
I. blastp compares a protein query to a protein database.
II. tblastx translates both a nucleotide query and a nucleotide database in all six reading frames.
III. blastn compares a translated nucleotide query to a protein database.
IV. blastx compares a translated nucleotide query to a protein database.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II, III and IV
(C) II, III and IV
(D) I and III

NODIA

2015

46. The Maximum Likelihood (ML) method for phylogenetic tree construction operates on which core statistical principle?
(A) Minimizing the total number of evolutionary steps required to explain the observed biological data
(B) Clustering taxa solely based on pairwise distance matrices calculated from the multiple alignment
(C) Finding the tree topology that makes the observed sequence data most probable under a specific model
(D) Assuming a strict molecular clock for all phylogenetic distances between the organisms in the study

2017

47. Which bioinformatics tool employs a consistency-based scoring mechanism, utilizing both global and local alignments, to improve multiple sequence alignment accuracy over progressive methods?
(A) ClustalW
(B) FASTA
(C) DotMatcher
(D) T-Coffee

2008

48. What is the fundamental challenge of clustering Expressed Sequence Tags (ESTs) originating from eukaryotic organisms?
(A) ESTs lack completely any nucleotide variations
(B) ESTs are exclusively double-stranded RNA
(C) Alternative splicing and sequencing errors can create chimeric or artefactual contigs
(D) Eukaryotic genomes completely lack poly-A tails

2010

49. In machine learning applied to QSAR, what is the primary role of Support Vector Machines (SVM)?
(A) To randomly assign biological activities regardless of molecular descriptors
(B) To construct optimal hyperplanes in a high-dimensional space to separate active from inactive compounds
(C) To strictly calculate raw molecular weights

(C) They do not utilize distance matrices
(D) They strictly generate unrooted phylogenetic trees

2017

68. Which phylogenetic terminology describes a taxon that diverges early in the evolutionary history of a clade and is used to root the tree?
(A) Ingroup
(B) Polytomy
(C) Outgroup
(D) Sister group

2013

69. Which substitution model utilized in Maximum Likelihood phylogenetics explicitly accounts for differing transition and transversion rates, as well as unequal base frequencies?
(A) General Time Reversible (GTR)
(B) Jukes-Cantor (JC_69)
(C) Kimura 2-Parameter (K2P)
(D) Felsenstein 81 (F81)

2022

70. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): cDNA libraries are fundamentally crucial for expressing eukaryotic proteins in prokaryotic systems like E. coli.
Reason (R): Prokaryotic transcription machinery cannot process and splice out eukaryotic introns present in genomic DNA.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

71. Identify the concept that best defines the principle of a pharmacophore in ligand-based drug design.
(A) The strict 3D arrangement of atoms within a protein receptor
(B) A specific spatial arrangement of steric and electronic features necessary for optimal supramolecular interactions with a specific biological target
(C) The synthesis route of an active pharmaceutical ingredient
(D) The calculation of a compound's molecular weight

2017

72. Which 3D QSAR technique places an active ligand on a fixed grid and measures interaction energies using steric (Lennard-Jones) and electrostatic (Coulombic) probes?
(A) MLR
(B) CoMSIA
(C) CoMFA
(D) Principal Component Analysis (PCA)

2009

73. In the context of the Random Forest machine learning technique, what does the algorithm primarily rely on to make its final prediction for classification problems?
(A) The single decision tree with the highest depth
(B) The absolute linear regression of the dataset
(C) The nearest Euclidean distance between neighbors
(D) A majority vote among an ensemble of independent decision trees

2016

74. Which of the following descriptors is explicitly considered a 2D topological descriptor in QSAR studies?
(A) Wiener index
(B) Molecular volume
(C) Dipole moment
(D) Solvent accessible surface area

2016

75. Consider the following statements about biological databases:
I. UniProtKB consists of SWISS-PROT and TrEMBL.
II. GenBank is maintained by the European Bioinformatics Institute (EBI).
III. PDB exclusively stores predicted structural models rather than experimental data.
IV. The DDBJ is a member of the INSDC.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II and III
(C) III and IV
(D) I and IV

2022

76. In agricultural bioinformatics, what is the primary purpose of constructing a composite database like InterPro?
(A) To integrate predictive models, protein signatures, and motifs from multiple databases into a single searchable resource

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IV. Structural databases lack coordinates for nucleic acids.

Which of the above statement(s) is/are INCORRECT?

(A) I, II and III
(B) II, III and IV
(C) IV only
(D) I and IV

2016

26. The Sequence Retrieval System (SRS) provides extensive cross-referencing capabilities. What is its fundamental architectural advantage over single-database search tools?

(A) It integrates flat-file indexing across diverse, disparate biological databases
(B) It utilizes dynamic programming for rapid sequence alignment
(C) It performs deep learning-based structure prediction
(D) It exclusively limits searches to proprietary commercial databases

2010

27. Identify the correct pair defining a sequence alignment parameter.

(A) Gap extension penalty - Penalty for initiating a gap in the alignment
(B) Gap opening penalty - Penalty for initiating a gap in the alignment
(C) Mismatch score - Positive reward for non-identical aligned residues
(D) Match score - Negative penalty for identical aligned residues

2021

28. Which characteristic fundamentally differentiates the BLOSUM matrix series from the PAM matrix series?

(A) BLOSUM is derived from global alignments of closely related sequences
(B) BLOSUM is based on observed frequencies in local alignments of conserved protein blocks
(C) BLOSUM matrices apply strictly to nucleotide alignments
(D) Higher BLOSUM numbers correspond to more divergent sequences

2002

29. The Smith-Waterman algorithm is biologically crucial for which of the following tasks?

(A) Identifying conserved functional domains within otherwise divergent protein sequences
(B) Aligning entire genomes uniformly from end to end
(C) Constructing phylogenetic trees directly from raw sequence data
(D) Translating an RNA sequence into protein

2017

30. Which of the following represents the correct sequence of steps typically followed in a BLAST algorithm search?

1. Extend the exact matches to find High-Scoring Segment Pairs (HSPs)
2. Compile a list of high-scoring words from the query sequence
3. Scan the database for exact matches to the word list
4. Evaluate the statistical significance (E-value) of the HSPs

(A) 2, 3, 1, 4
(B) 3, 2, 1, 4
(C) 1, 2, 4, 3
(D) 2, 1, 3, 4

NODIA

2006

31. Which feature in a multiple sequence alignment typically indicates a highly conserved structural or functional motif?

(A) A column containing entirely gaps
(B) High variance in residue properties within a localized block
(C) Random insertion events scattered throughout the alignment
(D) A column containing identical or chemically similar amino acids across all species

2016

32. In a phylogenetic tree, what does a root represent?

(A) An extant species at the tip of a branch
(B) A horizontal gene transfer event
(C) The hypothetical most recent common ancestor of all entities in the tree
(D) A node with exactly three descendant branches

2013

33. The Unweighted Pair Group Method with Arithmetic Mean (UPGMA) assumes which evolutionary condition to construct an ultrametric tree?

(A) A variable rate of molecular evolution across all lineages
(B) A strict molecular clock with a constant substitution rate
(C) Frequent hybridization events
(D) Back mutations and parallel substitutions

method.
IV. Bootstrapping provide statistical confidence for tree clades.
V. Cladograms indicate exact evolutionary time via branch lengths.
Which of the above statement(s) is/are correct?
(A) I, II and IV
(B) I, II, III and V
(C) II, III and IV
(D) I, IV and V

2011

86. Which statistical resampling technique is routinely used to estimate the reliability of specific clades within a generated phylogenetic tree?
(A) Jackknifing
(B) Markov Chain Monte Carlo
(C) Principal Component Analysis
(D) Bootstrapping

2024

87. In transcriptomics, what constitutes the primary biological material utilized for the generation of Expressed Sequence Tags (ESTs)?
(A) Telomeric DNA
(B) Messenger RNA (mRNA)
(C) Mitochondrial DNA
(D) Ribosomal RNA (rRNA)

2012

88. Which of the following describes a key advantage of utilizing open-source GPL bioinformatics software in agricultural research?
(A) It prevents external researchers from verifying the source code
(B) It eliminates all need for computational hardware
(C) It facilitates transparent, reproducible research and community-driven methodology enhancements
(D) It inherently guarantees correct biological conclusions

2005

89. Ligand-based drug design fundamentally assumes which of the following principles?
(A) Protein structures are entirely flexible and cannot be targeted
(B) De novo design is impossible without structural data
(C) High molecular weight compounds inherently have higher efficacy
(D) Structurally similar molecules tend to exhibit similar biological activities and bind to the same targets

2017

90. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): In molecular docking simulations, grid-based energy calculations significantly reduce computational time.
Reason (R): Precalculating receptor interaction potentials onto a 3D spatial grid avoids recalculating pairwise atomic interactions at every step of the ligand conformational search.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

91. Which specific physicochemical property evaluates a molecule's spatial bulk and atomic volume, acting as a critical parameter in QSAR steric field analysis?
(A) Electronegativity
(B) Molar refractivity
(C) Partition coefficient
(D) Dipole moment

2006

92. Identify the fundamental reason why accurate 3D conformation generation is imperative before performing CoMFA analysis.
(A) It calculates the precise molecular weight
(B) Interaction field descriptors are exquisitely sensitive to the precise 3D spatial alignment and superimposition of the ligand set
(C) CoMFA is entirely independent of spatial orientation
(D) It converts the 3D structures back into 1D SMILES strings

2002

93. What specific limitation of traditional Multiple Linear Regression (MLR) models in QSAR is addressed by utilizing Partial Least Squares (PLS) regression?
(A) MLR handles collinear descriptors poorly, whereas PLS reduces them into orthogonal latent variables
(B) MLR's inability to calculate *LogP* descriptors from the 2D molecular structures of the ligand set

NODIA

2. Target protein structure acquisition/ modeling
3. Lead optimization via QSAR
4. Molecular docking and scoring

(A) 2, 1, 4, 3
(B) 1, 2, 3, 4
(C) 2, 4, 1, 3
(D) 4, 2, 1, 3

2003

131. Which of the following defines a strict requirement for executing a successful ligand-based virtual screening campaign?
(A) Knowledge of at least one, and preferably several, known active small molecules against the target
(B) Complete structural resolution of the target receptor's active site
(C) The synthesis of all compounds in the database prior to screening
(D) The use of rigid-body docking exclusively

2022

132. Which thermodynamic component primarily drives the spontaneous binding of hydrophobic ligands into hydrophobic receptor pockets?
(A) Formation of covalent disulfide bonds
(B) Strong electrostatic repulsion
(C) Increase in entropy due to the release of ordered water molecules (desolvation)
(D) Decrease in overall system temperature

2021

133. What specific 2D QSAR descriptor, often denoted as π (Hansch constant) or $LogP$, fundamentally correlates with a drug's ability to cross biological membranes?
(A) Lipophilicity
(B) Steric bulk
(C) Dipole moment
(D) Molar refractivity

2011

134. Identify the correct statement detailing a key requirement for Comparative Molecular Field Analysis (CoMFA).
(A) It relies completely on 1D SMILES strings
(B) It automatically synthesizes the predicted compounds
(C) It only uses electrostatic fields, ignoring steric interactions
(D) All molecules in the dataset must be structurally superimposed based on a common pharmacophore or scaffold

2007

135. Consider the following statements about ML in bioinformatics:
I. Support Vector Machines utilize kernels to map data into higher dimensions for classification.
II. Random Forests are prone to massive overfitting on noisy datasets.
III. ANNs require a training dataset to adjust internal weights via backpropagation.
IV. Machine learning cannot be applied to QSAR.
V. K-means is an unsupervised learning clustering method.
Which of the above statement(s) is/are correct?
(A) I, III and V
(B) I, II, III and V
(C) II, IV and V
(D) I, III, IV and V

2021

136. Which database is considered the primary authoritative repository specifically for protein sequence and functional annotation?
(A) PDB
(B) dbEST
(C) UniProtKB
(D) Ensembl

2014

137. Which structural file format utilizes a hierarchical dictionary structure, allowing greater flexibility and extensibility than the legacy PDB format?
(A) FASTA
(B) FASTQ
(C) SMILES
(D) mmCIF (macromolecular Crystallographic Information File)

2013

138. Identify the database search engine developed specifically by the European Bioinformatics Institute (EBI) to replace SRS for rapid biological data retrieval.
(A) EB-eye (EBI Search)
(B) Entrez
(C) BLAST
(D) ExPASy

2017

139. In pairwise sequence alignment, an "identity" score strictly measures:
(A) The proportion of chemically similar amino acids
(B) The exact matches of characters in aligned positions

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(D) Identity matrix

2005

102. When interpreting a self-alignment dot plot, a line perpendicular to the main diagonal clearly signifies:
(A) A perfect identical match
(B) A gap insertion
(C) A frameshift mutation
(D) An inverted repeat or palindromic sequence

2002

103. In the Smith-Waterman algorithm, what critical rule allows the identification of local alignments rather than global ones?
(A) Gap penalties are completely ignored
(B) Negative scoring cells are reset to zero
(C) The traceback must start from the extreme bottom-right corner of the matrix
(D) Only exact matches are scored

2002

104. What is the fundamental difference in the "word size" (W) default parameter between blastn and blastp?
(A) blastn uses $W = 3$, while blastp uses $W = 11$
(B) They both strictly use $W = 5$
(C) blastn uses a larger word size (typically $W = 11$ or 28) because DNA alphabet is smaller, while blastp uses a smaller word size ($W = 3$)
(D) Word size is irrelevant in BLAST algorithms

2007

105. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Progressive multiple sequence alignments are highly dependent on the accuracy of the initial guide tree.
Reason (R): The algorithm permanently aligns the most closely related sequences first, and any errors made here cannot be corrected when more divergent sequences are added later.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2001

106. In multiple sequence alignments, what is the role of sequence weighting mechanisms (e.g., within ClustalW)?
(A) To down-weight highly similar sequences and up-weight divergent ones, preventing overrepresentation of a specific clade
(B) To multiply the length of shorter sequences to match longer ones
(C) To strictly penalize hydrophobic residues
(D) To automatically translate sequences into structural models

2009

107. Which cladistics term defines a phylogenetic group consisting of an ancestor and some, but not all, of its descendants?
(A) Monophyletic
(B) Paraphyletic
(C) Polyphyletic
(D) Synapomorphic

2005

108. Which distance-based phylogenetic algorithm explicitly relaxes the assumption of a strict molecular clock, permitting unequal evolutionary rates among lineages?
(A) UPGMA
(B) Neighbor-Joining (NJ)
(C) WPGMA
(D) Strict Parsimony

2005

109. What common computational step follows EST clustering to generate a consensus sequence in transcriptomic analysis?
(A) Contig assembly
(B) Whole genome duplication
(C) Reverse transcription
(D) Crystal structure prediction

NODIA

2011

110. Which of the following represents the correct hierarchical order of protein structure levels?
1. Quaternary structure (Subunit assembly)
2. Primary structure (Amino acid sequence)
3. Tertiary structure (3D folding)
4. Secondary structure (Alpha helices/Beta sheets)

(A) 2, 4, 3, 1
(B) 4, 2, 3, 1
(C) 2, 3, 4, 1
(D) 1, 3, 4, 2

2005

111. The Free Software Foundation (FSF) established the GPL to combat the restrictions of commercial software. Which of the following is NOT a protected right under GPL?
(A) The right to run the program for any purpose

(A) Direct rigid-body molecular docking
(B) Induced-fit docking
(C) Ligand-based drug design (e.g., pharmacophore modeling using known active compounds)
(D) De novo structure-based generation

2006

149. Identify the scoring function type that estimates binding free energy by explicitly calculating physical atomic interactions like van der Waals forces and electrostatics.
(A) Force-field-based scoring functions
(B) Empirical scoring functions
(C) Knowledge-based scoring functions
(D) Consensus scoring functions

2017

150. Match the QSAR variables (List I) with their definitions (List II):
List I: (QSAR Variables)
P. Dependent variable
Q. Independent variable
R. Descriptor
S. Regression model
List II: (Definitions)
1. The mathematical relationship connecting structure to activity
2. The physicochemical property calculated from the structure
3. The biological activity (e.g., IC_50) being predicted
4. The input variable (descriptor) used for prediction
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-1, R-4, S-2

2006

151. Which major limitation of CoMFA led to the development of the CoMSIA 3D QSAR technique?
(A) CoMFA's inability to calculate *LogP*
(B) The high sensitivity of CoMFA's Lennard-Jones potentials to slight changes in molecular superimposition, causing singularities near atomic centers
(C) CoMFA's exclusive reliance on 1D topological indices
(D) CoMFA's incompatibility with MLR

2001

152. In an Artificial Neural Network applied to QSAR, what is the function of the activation function within a hidden layer node?
(A) To randomly delete input variables
(B) To strictly calculate the molecular weight of the compound
(C) To introduce non-linearity into the model, allowing it to solve complex patterns
(D) To linearize the structural output for PCA

2010

153. GenBank assigns a unique alphanumeric string to every submitted sequence record that remains stable over time. What is this identifier called?
(A) GI number
(B) PubMed ID
(C) PDB code
(D) Accession number

2008

154. The European Molecular Biology Laboratory (EMBL) nucleotide database is principally hosted and maintained by which organization?
(A) EBI (European Bioinformatics Institute)
(B) NCBI
(C) CIB (Center for Information Biology)
(D) SIB (Swiss Institute of Bioinformatics)

2001

155. Which database provides an expertly curated, strictly non-redundant collection of reference sequences for genomes, transcripts, and proteins?
(A) dbEST
(B) RefSeq
(C) TrEMBL
(D) SRA (Sequence Read Archive)

2014

156. Entrez utilizes a highly interconnected architecture. What mechanism allows users to jump directly from a protein sequence record to the structural record of that protein?
(A) Dynamic programming alignments
(B) Entrez Neighbor/Link computations
(C) Hardlinks
(D) Heuristic E-values

2006

157. Which biological concept assumes that two sequences are homologous solely because they exhibit a statistically significant level of sequence similarity?
(A) Inference of homology
(B) Proof of xenology
(C) Measurement of identity

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2018

121. The sequence alignment parameter "Gap Extension Penalty" is generally:
(A) Much larger than the Gap Opening Penalty
(B) Equal to the Gap Opening Penalty
(C) A positive reward value
(D) Much smaller than the Gap Opening Penalty

2019

122. In the BLOSUM matrix derivation, what does the numeric value (e.g., 62 in BLOSUM62) signify?
(A) The matrix is derived from blocks of sequences sharing up to 62% identity
(B) The matrix penalizes gaps with a score of 62
(C) The matrix is suitable only for sequences 62 amino acids long
(D) The matrix represents 62 million years of evolution

2004

123. Identify the most biologically relevant application of the dot matrix method.
(A) Determining global evolutionary rates
(B) Visualizing large-scale genomic rearrangements, such as inversions and duplications
(C) Predicting the tertiary structure of proteins
(D) Calculating molecular weight

2022

124. Dynamic programming ensures mathematical optimality for sequence alignments. What is the fundamental mechanism of this approach?
(A) Randomly aligning sequences and picking the best empirical score
(B) Breaking the alignment problem into smaller, overlapping sub-problems and building the optimal solution in a tabular format
(C) Searching only for identical exact words of length 3
(D) Guessing the alignment based solely on sequence length

2010

125. Consider the following statements regarding BLAST statistics:
I. A lower E-value indicates a highly significant match.
II. The bit score is independent of the database size.
III. An E-value of 10 means 10 identical alignments are expected by chance.
IV. BLAST is a global alignment tool.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II and III
(C) III and IV
(D) IV only

2019

126. Which specific progressive multiple sequence alignment algorithmic step directly follows the calculation of the pairwise distance matrix?
(A) Translating sequences to proteins
(B) Calculating the final consensus sequence
(C) Constructing the guide tree
(D) Bootstrapping the phylogenetic tree

2019

127. Which metric is minimized in the Maximum Parsimony method of phylogenetic tree construction?
(A) Branch lengths reflecting time
(B) The likelihood function of the substitution model
(C) The geometric distance between operational taxonomic units
(D) The total number of evolutionary changes (substitutions) across the entire tree

2002

128. What does "homoplasy" refer to in the context of molecular phylogeny?
(A) Shared traits inherited from a recent common ancestor
(B) The exact root of the phylogenetic tree
(C) Similar traits evolved independently (convergence) or resulting from reversals, rather than common ancestry
(D) Perfect conservation of a nucleotide sequence across all domains of life

2017

129. Why is EST clustering critical before proceeding to functional annotation in transcriptomic studies?
(A) It ensures all ESTs are correctly reverse-translated back to genomic DNA
(B) It reduces redundancy by collapsing overlapping EST reads into singular representative consensus sequences
(C) It removes all stop codons from the sequences
(D) It physically separates RNA from DNA in the laboratory

NODIA

2014

130. Which of the following represents the correct workflow for utilizing CADD in novel inhibitor discovery?
1. Virtual screening of compound libraries

(B) The right to study how the program works
(C) The right to redistribute copies
(D) The right to monopolize and close the source code of derivative works

2004

112. Identify the INCORRECT statement regarding structure-based molecular docking.
(A) It requires the 3D coordinates of the target binding site
(B) It aims to predict the preferred orientation of a ligand when bound to a receptor
(C) It completely ignores the steric hindrance of the receptor pocket
(D) It evaluates interactions using mathematical scoring functions

2025

113. In molecular docking, "induced fit" refers to which biological phenomenon?
(A) The rapid denaturation of the receptor upon binding
(B) The conformational adjustment of both the ligand and the active site of the receptor to optimize binding interactions
(C) The purely random collision of molecules in a solvent
(D) The covalent bonding of all ligands unconditionally

2018

114. Which specific descriptor type in QSAR directly reflects the distribution of electronic charges across a molecule, influencing dipole moments and electrostatic interactions?
(A) Topological descriptors
(B) Geometric descriptors
(C) Thermodynamic descriptors
(D) Electronic descriptors

2004

115. Consider the following statements about QSAR and CADD:
I. CoMFA utilizes a grid-based approach to calculate interaction fields.
II. QSAR strictly ignores quantitative biological activity.
III. Ligand-based design relies on pharmacophore modeling when the receptor structure is unknown.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2024

116. Which machine learning methodology relies on biological neurons' conceptual architecture, utilizing hidden layers to map complex, non-linear relationships in QSAR?
(A) Partial Least Squares
(B) Random Forests
(C) Artificial Neural Networks (ANN)
(D) K-Means Clustering

2013

117. Agricultural bioinformatics utilizes genomic databases to enhance crop resilience. Which primary nucleotide database is explicitly maintained by Japan?
(A) DDBJ
(B) GenBank
(C) EMBL
(D) PDB

2025

118. Which statement best defines a "composite" biological database?
(A) It generates 3D structures directly from mass spectrometry
(B) It stores exclusively unannotated nucleotide reads
(C) It contains solely proprietary, unshared commercial data
(D) It integrates and cross-references data from multiple primary and secondary databases into a single interface

2019

119. In UniProtKB, what specific process elevates a TrEMBL entry to a SWISS-PROT entry?
(A) Automated translation of an EST
(B) Manual curation, literature review, and expert annotation
(C) Computational structure prediction via AlphaFold
(D) Random selection by the INSDC committee

2004

120. Which of the following represents the correct progression of sequence alignment algorithms from purely global, to purely local, to rapid heuristic search?
1. FASTA/BLAST
2. Smith-Waterman
3. Needleman-Wunsch
(A) 2, 3, 1
(B) 3, 2, 1
(C) 1, 2, 3
(D) 3, 1, 2

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(C) The evolutionary distance in millions of years
(D) The sum of gap penalties

2002

140. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): The PAM250 matrix is highly suitable for aligning distantly related protein sequences.
Reason (R): It represents an evolutionary model where 250 point mutations have occurred per 100 amino acids, reflecting deep evolutionary time.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

141. The Smith-Waterman algorithm differs mathematically from Needleman-Wunsch primarily through which specific operation?
(A) Terminating the traceback when a zero is reached, avoiding negative cumulative scores
(B) Allowing diagonal movements in the traceback
(C) Using purely heuristic word matches
(D) Requiring identical sequence lengths

2004

142. Which BLAST parameter controls the statistical significance threshold for reporting alignments, filtering out low-quality chance matches?
(A) Word size (W)
(B) Gap opening penalty
(C) Expectation value (E-value) cutoff
(D) Substitution matrix selection

2011

143. Which multiple sequence alignment strategy uses both local and global alignment profiles to build a highly accurate, consistency-based alignment?
(A) ClustalW
(B) BLASTp
(C) FASTA
(D) T-Coffee

2001

144. Which phylogenetic tree topology directly depicts the temporal sequence of evolutionary branchings by locating a definitive common ancestor node?
(A) Unrooted tree
(B) Radial cladogram
(C) Rooted tree
(D) Star phylogeny

NODIA

2025

145. Match the phylogenetic methods (List I) with their fundamental principles (List II):
List I: (Phylogenetic Methods)
P. UPGMA
Q. Neighbor-Joining
R. Maximum Parsimony
S. Maximum Likelihood
List II: (Fundamental Principles)
1. Minimizes total evolutionary steps
2. Maximizes the probability of observing the sequence data under an evolutionary model
3. Sequential clustering assuming equal evolutionary rates
4. Star decomposition method that minimizes overall tree length
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2001

146. Which bioinformatics protocol is strictly necessary to clean raw EST sequences before clustering and assembly?
(A) Translating all sequences to proteins
(B) Simulating molecular docking
(C) Aligning to the PDB database
(D) Vector and adapter trimming

2019

147. What primary legal distinction separates commercial bioinformatics software from GPL open-source software?
(A) Commercial software restricts source code modification and redistribution via proprietary licenses
(B) Commercial software cannot be installed on Linux
(C) GPL software completely prohibits any scientific publication
(D) Commercial software strictly utilizes only heuristic algorithms

2002

148. Which approach is utilized when attempting Computer-Aided Drug Design (CADD) against a novel viral protein whose 3D structure is completely unknown and lacks structural homologs?

(C) MLR inherently requires 3D superimposition of the ligand set using a common scaffold or template
(D) MLR limits models to a single input descriptor rather than multiple independent structural variables

2017

94. The central dogma of molecular biology was modified to incorporate the discovery of which enzyme, responsible for synthesizing DNA from an RNA template?
(A) DNA polymerase
(B) RNA polymerase
(C) Reverse transcriptase
(D) Peptidyl transferase

2001

95. Match the databases (List I) with their primary data types (List II):
List I: (Databases)
P. GenBank
Q. SWISS-PROT
R. PDB
S. PROSITE
List II: (Data Types)
1. Annotated protein sequences
2. Nucleotide sequences
3. Protein domains, families, and functional sites
4. 3D macromolecular structures
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

2015

96. What is the fundamental organizational difference between UniProtKB/SWISS-PROT and the PIR database?
(A) PIR lacks any protein sequence data
(B) UniProtKB strictly organizes by protein superfamilies, while PIR organizes exclusively by taxonomy
(C) PIR was historically organized into superfamilies and aligned families, which later contributed to the unified UniProt consortium
(D) SWISS-PROT contains exclusively structural data

2004

97. In structural bioinformatics, what is the role of the HETATM record in a PDB file?
(A) It specifies standard amino acid residues
(B) It delineates non-standard groups, such as ligands, cofactors, and bound water molecules
(C) It describes the overall helical topology
(D) It provides the literature citation for the structure

2019

98. Which sequence retrieval system uses Boolean operators (AND, OR, NOT) comprehensively across interconnected NCBI databases to refine user queries?
(A) SRS
(B) BLAST
(C) FASTA
(D) Entrez

2007

99. The concept of "identity" in sequence alignment strictly refers to:
(A) The ratio of identical amino acid/nucleotide residues aligned exactly in the same column
(B) The overall evolutionary relationship between sequences
(C) Matches that include chemically similar, but not identical, residues
(D) The statistical significance of the gap penalty

2018

100. Match the sequence analysis terms (List I) with their defining properties (List II):
List I: (Sequence Analysis Terms)
P. Orthologs
Q. Paralogs
R. Analogs
S. Homologs
List II: (Defining Properties)
1. Result from speciation events
2. Broad term for evolutionary relatedness
3. Evolve convergent functions without common ancestry
4. Result from gene duplication events
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-1, R-2, S-3
(C) P-1, Q-3, R-4, S-2
(D) P-2, Q-1, R-4, S-3

2024

101. Which mathematical matrix calculates similarity scores based directly on the log-odds ratio of observed versus expected amino acid substitution frequencies?
(A) PAM matrix
(B) Dynamic matrix
(C) Distance matrix

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(D) Calculation of gap penalties

2023

158. Identify the INCORRECT statement regarding gap penalties in sequence alignments.
(A) A gap represents an insertion or deletion evolutionary event
(B) Affine gap models provide more biologically realistic alignments than linear gap models
(C) The gap opening penalty is generally smaller than the gap extension penalty
(D) High gap penalties force the alignment algorithm to minimize the introduction of gaps

2012

159. Which substitution matrix is generated by calculating the log-odds ratio of actual observed substitutions in locally aligned blocks of conserved sequences?
(A) PAM matrix
(B) Identity matrix
(C) Distance matrix
(D) BLOSUM matrix

2012

160. Which of the following represents the exact procedural order for constructing a multiple sequence alignment using the progressive method?
1. Progressively align sequences following the branching order of the tree
2. Calculate all pairwise alignment distances
3. Generate a distance matrix
4. Construct a guide tree
(A) 2, 3, 4, 1
(B) 3, 2, 4, 1
(C) 4, 3, 2, 1
(D) 2, 4, 3, 1

2005

161. In global alignment dynamic programming, the final optimal alignment score is typically located where in the scoring matrix?
(A) In the top-left cell
(B) In the bottom-right cell representing the end of both sequences
(C) In the exact center cell
(D) Spread across the entire first row

2017

162. FASTA is highly efficient because it initially searches for identical short sequences. What are these short sequences formally called?
(A) Nodes
(B) Clades
(C) Pharmacophores
(D) K-tuples or words

2012

163. Which BLAST program requires the heaviest computational load because it executes translations of both the query and the database into all six reading frames?
(A) tblastx
(B) blastn
(C) tblastn
(D) blastx

2001

164. In ClustalW, how do position-specific gap penalties improve alignment accuracy?
(A) By completely forbidding gaps in hydrophilic regions
(B) By assigning identical penalties to all positions
(C) By increasing gap penalties within hydrophobic core regions (which rarely tolerate insertions/deletions) and decreasing them in hydrophilic surface loop regions
(D) By strictly aligning only exact matches

2018

165. Which term best characterizes an evolutionary tree where the branch lengths are proportional to the amount of evolutionary change or time?
(A) Phylogram
(B) Cladogram
(C) Dendrogram
(D) Venn diagram

2023

166. Maximum Parsimony is generally most effective and accurate under which of the following conditions?
(A) When evolutionary rates are extremely high and variable
(B) When sequences belong to completely distinct domains of life
(C) When analyzing unaligned random nucleotide sequences
(D) When sequences are closely related and the amount of homoplasy is low

2011

167. Which transcriptomic technique strictly relies on counting the frequency of short, specific sequence tags to quantify gene expression levels?
(A) Microarray hybridization
(B) SAGE (Serial Analysis of Gene Expression)
(C) Western blotting
(D) CoMFA

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2016

168. Which feature makes the Python programming language and its Biopython library highly favored in the bioinformatics software ecosystem?
(A) It strictly compiles to closed-source binary code
(B) It requires commercial licensing for academic use
(C) It provides extensive open-source modules for sequence parsing, alignment tools, and database interactions
(D) It only operates on Windows operating systems

2002

169. What critical assumption underpins the strategy of structure-based drug design (SBDD)?
(A) The drug molecule must be completely rigid
(B) The target protein must be an enzyme
(C) Ligands are generated exclusively via random high-throughput synthesis
(D) The 3D geometry and physicochemical properties of the receptor's binding site determine the binding affinity of the ligand

2016

170. Which molecular docking search algorithm utilizes principles of natural selection—mutation, crossover, and survival of the fittest—to explore the ligand conformational space?
(A) Genetic Algorithms
(B) Simulated Annealing
(C) Monte Carlo methods
(D) Systematic Incremental Construction

2014

171. In QSAR, the Taft steric parameter (E_s) is utilized specifically to measure:
(A) The electronic inductive effect
(B) The steric bulk of a substituent relative to a methyl group
(C) The partition coefficient
(D) The polarizability of the entire molecule

2012

172. Which statistical metric is fundamentally used in QSAR to evaluate the external predictive ability of a developed mathematical model?
(A) The coefficient of determination (r^2) of the training set
(B) Cross-validated q^2 or external $R^2_{\{pred\}}$
(C) The raw molecular weight of the ligands
(D) The sum of squared errors in the guide tree

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2019

173. What explicit computational advantage does Support Vector Regression (SVR) offer over simple Multiple Linear Regression (MLR) in complex QSAR studies?
(A) SVR easily models highly non-linear relationships by utilizing kernel functions to map data into high-dimensional feature spaces
(B) SVR cannot handle multiple variables
(C) SVR strictly limits models to 2D topological descriptors
(D) SVR entirely ignores all inactive compounds

2024

174. Which of the following best defines the "translation" step within the central dogma of agricultural bioinformatics?
(A) Copying DNA into mRNA
(B) Replicating the viral RNA genome
(C) Synthesizing a polypeptide chain from an mRNA template at the ribosome
(D) Processing primary RNA transcripts by splicing

2019

175. Consider the following statements regarding protein databases:
I. PRINTS is a primary database storing raw sequence reads.
II. Pfam is a database of protein families represented by Multiple Sequence Alignments and Hidden Markov Models.
III. PROSITE utilizes regular expressions to define functional motifs.
IV. UniProt integrates SWISS-PROT, TrEMBL, and PIR.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) II, III and IV
(C) I, III and IV
(D) I and II

2021

176. Which major biological database consortium strictly synchronizes nucleotide sequence data on a daily basis to maintain global consistency?
(A) wwPDB
(B) ExPASy
(C) INSDC
(D) RCSB

2001

177. PDB structures are most commonly determined experimentally using which two primary techniques?

(A) Mass spectrometry and Western blotting
(B) X-ray crystallography and Nuclear Magnetic Resonance (NMR) spectroscopy
(C) PCR and Sanger sequencing
(D) Flow cytometry and ELISA

2019

178. What critical function does a "Boolean AND" operator perform when querying the Entrez system?
(A) It expands the search to include either of the terms
(B) It explicitly excludes a specific term from the search
(C) It translates the query into structural coordinates
(D) It restricts the search to records that contain both queried terms, narrowing the results

2022

179. Identify the correct pair associating an evolutionary relationship with its defining origin.
(A) Xenologs - Origin via horizontal gene transfer
(B) Orthologs - Origin via gene duplication
(C) Paralogs - Origin via speciation
(D) Analogs - Origin via direct vertical inheritance

2010

180. The PAM1 matrix represents an evolutionary distance where what percentage of amino acids have undergone substitution?
(A) 10%
(B) 100%
(C) 1%
(D) 0.1%

2001

181. Why are BLOSUM matrices generally considered superior to PAM matrices for detecting distant evolutionary relationships in local alignments?
(A) BLOSUM is derived from conserved protein blocks, avoiding mathematical extrapolation errors
(B) BLOSUM assumes a strictly linear mutation rate over billions of years of molecular evolution
(C) BLOSUM penalizes all gaps identically regardless of the specific biological sequence context
(D) PAM matrices are restricted exclusively to nucleotide sequences found in prokaryotic genomes

2002

182. When using dynamic programming for local alignment, how does the Smith-Waterman matrix effectively restart an alignment when the score drops below biological relevance?
(A) By assigning negative scores and terminating the program
(B) By skipping the current sequence entirely
(C) By automatically adopting global alignment protocols
(D) By restricting scores from falling below zero, placing a 0 in the cell instead of a negative number

2002

183. Identify the fundamental factor that determines the significance of an E-value in a BLAST search.
(A) The exact time of day the search is run
(B) The scoring matrix, gap penalties, sequence length, and the total size of the searchable database
(C) Only the length of the query sequence
(D) The alphabetical order of the nucleotide bases

2013

184. In multiple sequence alignment, the phenomenon where unrelated sequences are misaligned due to strict adherence to the initial guide tree is known as:
(A) The local minimum problem during the optimization phase
(B) The molecular clock paradox in phylogenetic constructions
(C) Errors in early alignment stages that cannot be corrected
(D) The dynamic threshold error during the gap penalty phase

2016

185. Which component of a phylogenetic tree represents an extant, living taxonomic unit directly observed and sampled by the researcher?
(A) Internal node
(B) Root
(C) Branch length
(D) Leaf/Terminal node

2016

186. Which phylogenetic analysis explicitly relies on the principle of Occam's razor, selecting the evolutionary hypothesis requiring the fewest assumptions?
(A) Maximum Parsimony
(B) Maximum Likelihood
(C) Bayesian Inference

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(A) Maximum Parsimony
(B) Maximum Likelihood
(C) UPGMA
(D) Neighbor-Joining

2010

225. In the context of transcriptomics, what constitutes the "cleaning" phase of EST processing?
(A) Removing completely intact genomic sequences
(B) Computationally stripping out vector, adapter, primer, and low-quality sequences
(C) Translating the sequence into 3D structural coordinates
(D) Grouping identical reads into contigs

2012

226. Which open-source license strictly requires that any derived software mathematically integrating the original code must also be released openly under the identical license?
(A) MIT License
(B) Apache 2.0 License
(C) Proprietary Commercial License
(D) GNU General Public License (GPL)

2009

227. In ligand-based drug design, a pharmacophore defines:
(A) The spatial ensemble of steric and electronic features necessary to ensure optimal interactions with a biological target
(B) The structural sequence of the target protein
(C) The synthetic chemical pathway of the ligand
(D) The absolute molecular weight of the compound

2022

228. Which molecular docking search algorithm systematically constructs the ligand within the binding site by placing a rigid core fragment and iteratively adding flexible side chains?
(A) Molecular Dynamics simulations of the entire receptor-ligand complex in a water box
(B) Genetic Algorithms utilizing mutation and crossover to explore the conformational space
(C) Incremental Construction by placing a core fragment and adding flexible side chains
(D) Simulated Annealing by heating and cooling the system to find the global energy minimum

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2022

229. Which mathematical technique is fundamentally utilized in 3D QSAR CoMFA to extract principal components from thousands of highly collinear 3D field descriptors?
(A) Partial Least Squares (PLS) Regression
(B) Multiple Linear Regression (MLR)
(C) Fast Fourier Transform (FFT)
(D) K-Means Clustering

2025

230. Which of the following represents the correct sequential protocol for preparing a protein receptor for molecular docking?
1. Addition of polar hydrogens
2. Removal of unbound water molecules and co-crystallized solvents
3. Calculation of partial atomic charges (e.g., Gasteiger charges)
4. Download structural coordinates from PDB

(A) 4, 2, 1, 3
(B) 4, 1, 2, 3
(C) 2, 4, 1, 3
(D) 1, 2, 3, 4

2014

231. Which machine learning approach constructs an optimal separating hyperplane in high-dimensional space, maximizing the margin between structurally diverse active and inactive compounds?
(A) Random Forests constructing an ensemble of trees to vote on the final predicted class
(B) Support Vector Machines (SVM) maximizing the margin between the active/inactive classes
(C) Naive Bayes utilizing conditional probabilities to predict the likelihood of activity
(D) Principal Component Analysis reducing the dimensionality of the input descriptor matrix

2019

232. Which of the following biological databases is a primary repository for experimentally determined nucleotide sequences maintained by the NCBI?
(A) SWISS-PROT
(B) PDB
(C) GenBank
(D) PROSITE

2024

233. When retrieving nucleotide data via SRS or Entrez, utilizing the FASTA format outputs:
(A) Only the raw sequence without any identifier

2006

196. In a standard protein FASTA format, what character designates the mandatory description line preceding the sequence string?
(A) @
(B) #
(C) >
(D) $

2013

197. Which of the following structural file formats is explicitly designed to handle exceptionally large macromolecular complexes (e.g., ribosomes) that exceed the atom limit of legacy PDB format?
(A) PDBx/mmCIF
(B) SMILES
(C) FASTQ
(D) GFF_3

2008

198. Which query strategy within Entrez effectively retrieves all literature publications authored by a specific individual?
(A) Searching the protein database using blastp
(B) Performing a multiple sequence alignment
(C) Downloading the entire PubMed FTP directory
(D) Using the [AU] or [Author] search field tag

2021

199. What fundamental assumption allows bioinformatics algorithms to deduce structural or functional similarity between two newly discovered proteins?
(A) Convergent evolution guarantees structural identity
(B) High primary sequence homology heavily implies shared structural topology and biological function
(C) All proteins naturally fold into alpha helices
(D) Biological databases filter out structurally diverse proteins

2007

200. Match the BLAST variants (List I) with their query-database combinations (List II):
List I: (BLAST Variants)
P. blastp
Q. blastn
R. blastx
S. tblastn
List II: (Query-Database Combinations)
1. Translated nucleotide query against protein database
2. Protein query against translated nucleotide database
3. Nucleotide query against nucleotide database
4. Protein query against protein database
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-3, R-2, S-1
(D) P-1, Q-2, R-3, S-4

2024

201. The Needleman-Wunsch algorithm utilizes a traceback procedure. Where does this traceback initiate?
(A) At the cell with the highest absolute score in the entire matrix
(B) At the top-left cell $(0,0)$
(C) At the first cell containing a gap penalty
(D) At the bottom-right cell representing the end of both sequences

2005

202. Which specific heuristic alignment algorithm achieves extreme speed by compiling a dictionary of exact sequence matches (words/k-tuples) and utilizing a deterministic finite automaton?
(A) FASTA
(B) Needleman-Wunsch
(C) UPGMA
(D) Maximum Parsimony

2010

203. In progressive multiple sequence alignments, what problem occurs if an incorrect gap is introduced early in the alignment of the most closely related sequences?
(A) The algorithm immediately crashes
(B) The gap propagates inflexibly throughout the entire final alignment
(C) The gap is automatically erased by the consensus algorithm
(D) The sequences are translated to proteins

2016

204. Which parameter in ClustalW prevents gaps from being inserted inside highly conserved secondary structure regions (e.g., alpha-helices)?
(A) Matrix selection
(B) Position-specific gap penalties utilizing structural masks
(C) Gap extension penalty reduction
(D) E-value threshold

2017

205. Identify the fundamental characteristic of an unrooted phylogenetic tree.
(A) It illustrates relationships among taxa without specifying the evolutionary path or direction

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(B) It clearly identifies the most recent common ancestor for all organisms within the study
(C) It explicitly plots time on the y-axis to show the chronological sequence of all events
(D) It only contains two taxa that are compared directly against a known outgroup sequence

2017

206. Which sequence-based phylogenetic tree construction method calculates the likelihood of observing the specific nucleotide alignment under a rigorous model of molecular evolution?
(A) Neighbor-Joining
(B) UPGMA
(C) Maximum Likelihood
(D) Maximum Parsimony

2018

207. During transcriptome analysis, what bioinformatic tool is typically used to rapidly map raw RNA-Seq reads to a reference genome?
(A) Clustal Omega
(B) CoMFA
(C) T-Coffee
(D) Hisat2 / STAR (Splice-aware aligners)

2004

208. The term "de novo drug design" in agricultural bioinformatics implies:
(A) Screening a library of existing known pesticides
(B) Re-purposing an FDA-approved drug
(C) Constructing novel ligand molecules entirely from scratch within the spatial constraints of the target receptor pocket
(D) Utilizing pure ligand-based QSAR models

2003

209. Which scoring function incorporates explicit quantum mechanical descriptors and extensive thermodynamic sampling, though it is often computationally prohibitive for high-throughput docking?
(A) Empirical scoring
(B) Free Energy Perturbation (FEP)
(C) Knowledge-based scoring
(D) Shape-matching scoring

2023

210. What specific molecular descriptor calculates the distribution of topological distances between all pairs of carbon atoms in an alkane framework?
(A) Partition coefficient
(B) Molar refractivity
(C) Dipole moment
(D) Wiener Index

2023

211. Which statistical validation parameter represents the leave-one-out cross-validated correlation coefficient, critical for assessing the internal robustness of a QSAR model?
(A) q^2
(B) R^2
(C) Standard error of estimate (s)
(D) F-statistic

2006

212. Identify the primary advantage of utilizing Artificial Neural Networks (ANNs) for predicting the biological activity of novel agrochemicals.
(A) They strictly define clear, linear equations easily interpreted by synthetic medicinal chemists
(B) They do not require any input descriptors to accurately predict the biological activity levels
(C) They can model complex, non-linear relationships between molecular descriptors and toxicity
(D) They automatically synthesize the compounds using automated robotic liquid handling systems

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2012

213. According to the central dogma, genetic information cannot flow backward from which biological macromolecule?
(A) Protein to Protein or Protein to Nucleic Acid
(B) DNA to RNA
(C) RNA to DNA
(D) DNA to DNA

2007

214. Which biological database integrates structural data with sequence data, explicitly providing 2D topology and domain architecture visual summaries of PDB entries?
(A) GenBank
(B) dbEST
(C) TrEMBL
(D) PDBsum

2010

215. Consider the following statements regarding the INSDC:
I. It comprises GenBank, EMBL, and DDBJ.
II. All data submitted to one database is synchronized globally.
III. It exclusively archives proprietary commercial sequences.
Which of the above statement(s) is/are correct?

(A) I and II
(B) II and III
(C) I and III
(D) I only

2008

216. Which database query formulation effectively retrieves nucleotide sequences pertaining to drought tolerance in Triticum aestivum (wheat) from Entrez?
(A) "drought" OR "Triticum aestivum"
(B) "drought" NOT "Triticum aestivum"
(C) "drought"[All Fields] AND "Triticum aestivum"[Organism] AND biomol_genomic[PROP]
(D) "Triticum aestivum" [Author]

2008

217. When comparing sequence identity vs. similarity, why is a high similarity score more biologically meaningful than a moderate identity score for distantly related proteins?
(A) Identity ignores the length of the sequences being compared in the global alignment matrix
(B) Identity strictly calculates nucleotide transversions rather than focusing on amino acids
(C) Similarity is completely independent of the evolutionary history of the organisms in study
(D) Similarity accounts for substitutions that preserve biochemical properties and 3D folding

2002

218. What is the fundamental evolutionary reason for selecting the BLOSUM45 matrix over BLOSUM62 when aligning two distantly related proteins?
(A) BLOSUM45 is derived from highly conserved blocks with only 45% sequence identity, capturing deep evolutionary divergence
(B) BLOSUM45 enforces strict identity matching
(C) BLOSUM45 contains higher gap penalties
(D) BLOSUM45 is restricted to RNA alignments

2015

219. In a dot matrix plot, what structural feature is indicated by a diagonal line running strictly parallel, but offset, from the central identity diagonal?
(A) A palindromic sequence
(B) A direct repeat
(C) A major deletion
(D) A point mutation

2015

220. Which dynamic programming algorithm calculates a matrix where the final alignment score is found by searching the entire matrix for the maximum absolute value?
(A) Needleman-Wunsch
(B) Smith-Waterman
(C) UPGMA
(D) Maximum Parsimony

2003

221. Which explicit statistical distribution describes the occurrence of random match scores in local sequence alignments, forming the basis of BLAST's E-value calculation?
(A) Extreme Value Distribution (Gumbel distribution)
(B) Normal distribution
(C) Binomial distribution
(D) Poisson distribution

2008

222. Identify the INCORRECT statement regarding the ClustalW multiple sequence alignment algorithm.
(A) It calculates a distance matrix from all pairwise alignments between the input biological sequences
(B) It builds a guide tree using the Neighbor-Joining method to direct the progressive alignment steps
(C) It utilizes an unchanging substitution matrix for all sequences regardless of evolutionary distance
(D) It aligns sequences progressively from the most closely related pairs to the most divergent groups

2019

223. What fundamental structural characteristic defines a "rooted" phylogenetic tree?
(A) A circular, radial topology with no internal nodes
(B) The explicit mapping of geographic locations to taxa
(C) The complete absence of branch length data
(D) The presence of a single node representing the most recent common ancestor of all entities in the tree

2016

224. Which phylogenetic tree construction algorithm explicitly generates an ultrametric tree, assuming uniform evolutionary rates across all branches?

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2008

242. Maximum Likelihood phylogenetics evaluates tree topologies using an explicit model of sequence evolution. Which model accounts for unequal base frequencies and specific distinct rates for all six possible nucleotide substitutions?
(A) Jukes-Cantor (JC)
(B) Kimura 2-Parameter (K2P)
(C) Felsenstein 81 (F81)
(D) General Time Reversible (GTR)

2013

243. What bioinformatic output is explicitly generated when overlapping clean EST sequences are computationally assembled?
(A) A contig (contiguous sequence)
(B) A proteome map
(C) A 3D receptor grid
(D) A phylogenetic star tree

2011

244. What defines a "commercial software ecosystem" in bioinformatics?
(A) Complete algorithmic transparency
(B) Free redistribution of all compiled binaries
(C) Software source code is proprietary, highly maintained, and licensed for a fee, providing standardized interfaces and support
(D) Exclusive focus on command-line Linux interfaces

2023

245. Identify the correct pair associating a CADD strategy with its core requirement.
(A) Structure-based design - Requires known active ligands
(B) Ligand-based design - Requires known active ligands
(C) Molecular docking - Requires only 1D sequence data
(D) CoMFA - Requires the 3D structure of the target receptor

2014

246. Which fundamental biophysical process is simulated during the "pose generation" step of a molecular docking workflow?
(A) The synthetic chemical reaction creating the ligand
(B) The translation of mRNA into the receptor protein
(C) The crystallization of the protein
(D) The geometric and conformational exploration of the ligand fitting into the receptor's active site

2007

247. Which specific molecular descriptor calculates the branching and size of a molecule utilizing a hydrogen-suppressed molecular graph?
(A) Partition coefficient (LogP)
(B) Randic topological index
(C) Dipole moment
(D) Molar volume

2002

248. In 3D QSAR methodology, what specific mathematical operation avoids the division-by-zero singularities encountered in the electrostatic/steric fields of CoMFA?
(A) Eliminating all field calculations entirely to simplify the overall statistical analysis
(B) Applying standard MLR to a reduced set of descriptors chosen by a genetic algorithm
(C) Utilizing a distance-dependent Gaussian function in CoMSIA to avoid field singularities
(D) Replacing 3D coordinates with SMILES strings to calculate purely topological descriptors

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2002

249. Which machine learning methodology inherently provides an assessment of descriptor importance by monitoring the decrease in accuracy when specific variables are randomly permuted during the construction of an ensemble of trees?
(A) SVM
(B) K-Means
(C) ANN
(D) Random Forests

2025

250. Match the software tools (List I) with their primary bioinformatic application (List II):
List I: (Software Tools)
P. ClustalW
Q. AutoDock
R. MEGA
S. BLAST
List II: (Primary Applications)
1. Molecular docking
2. Rapid heuristic database searching
3. Multiple sequence alignment
4. Phylogenetic tree construction and analysis
(A) P-3, Q-1, R-4, S-2
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

(B) A highly formatted table with atomic coordinates
(C) A comprehensive functional annotation summary
(D) A definition line beginning with '>' followed by sequence characters

2011

234. Which specific scoring term is exclusively applied when a sequence alignment introduces a new, continuous gap in an otherwise contiguous sequence?
(A) Gap opening penalty
(B) Mismatch score
(C) Gap extension penalty
(D) Match reward

2021

235. Consider the following statements about alignment matrices:
I. PAM matrices are based on an explicitly defined evolutionary model.
II. BLOSUM matrices are derived empirically from highly conserved sequence blocks.
III. BLOSUM80 is suited for highly divergent sequences.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II and III
(C) III only
(D) I and III

2018

236. Which dot matrix filtering rule optimally reduces random background noise while preserving significant local alignments?
(A) Scoring 1 for a match and 0 for a mismatch with no windowing
(B) Requiring M matches within a sliding window of length W
(C) Deleting all diagonal lines
(D) Requiring the entire sequence to match perfectly

2006

237. The Smith-Waterman algorithm calculates optimal local alignments. Why is it generally avoided for searching entire multi-gigabyte genomic databases?
(A) Its dynamic programming nature makes it computationally prohibitive for massive databases
(B) It completely fails to align short sequences when the gap opening penalties are high
(C) It requires strictly linear gap penalties rather than the more realistic affine models
(D) It inherently produces unrooted phylogenetic trees that lack a common ancestral node

2014

238. In the FASTA heuristic, what parameter fundamentally defines the length of the initial identical match required to initiate an alignment?
(A) E-value
(B) Bit score
(C) k-tuple (word size)
(D) Gap opening penalty

2017

239. Which BLAST program provides the highest sensitivity for finding distantly related protein homologs by constructing a position-specific scoring matrix (PSSM) through iterative database searches?
(A) blastn
(B) blastx
(C) tblastx
(D) PSI-BLAST

2019

240. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Iterative alignment algorithms consistently produce higher-quality alignments than strict progressive algorithms for distantly related sequences.
Reason (R): Iterative algorithms perform repeated cycles of realignment, escaping the local minimum errors trapped in the initial guide tree of progressive methods.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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2024

241. Which method defines phylogenetic clades based strictly on synapomorphies (shared derived characters)?
(A) Phenetics
(B) Cladistics
(C) Transcriptomics
(D) Pharmacokinetics

(D) Neighbor-Joining

2017

187. In transcriptomic bioinformatics, what specific characteristic defines an EST (Expressed Sequence Tag)?
(A) A fully sequenced, completely assembled whole genome
(B) A short (200-800 bp), unedited sequence read from either the 5' or 3' end of a cDNA clone
(C) A pure intronic sequence translated to protein
(D) A predicted 3D structural motif

2010

188. Which statement correctly contrasts commercial software with open-source (GPL) software in bioinformatics?
(A) Commercial software is legally free to redistribute among various research labs
(B) Commercial software source code is hidden, whereas open-source code is transparent
(C) Open-source software provides dedicated 24/7 corporate customer support for users
(D) Open-source software is strictly forbidden in agricultural research and development

2004

189. Molecular docking protocols generally consist of which two interconnected computational tasks?
(A) Pose generation (search algorithm) and binding affinity evaluation (scoring function)
(B) Gene expression profiling and EST clustering
(C) Guide tree construction and multiple sequence alignment
(D) Motif searching and literature retrieval

2017

190. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): In 3D QSAR methodologies like CoMFA, aligning (superimposing) the ligand dataset is the most critical and sensitive step.
Reason (R): CoMFA calculates interaction fields at fixed grid points; poor superimposition leads to mismatched spatial coordinates, rendering the calculated steric and electrostatic fields biologically meaningless.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

191. Which of the following descriptors is exclusively derived from the 3D atomic coordinates of a molecule?
(A) Molecular weight
(B) Constitutional descriptors (atom counts)
(C) Number of rotatable bonds
(D) Solvent accessible surface area (SASA)

2023

192. Which machine learning classifier fundamentally constructs decision boundaries by mapping input descriptors into high-dimensional space to maximize the margin between active and inactive compounds?
(A) Artificial Neural Networks
(B) Random Forests
(C) Support Vector Machines (SVM)
(D) Partial Least Squares

2016

193. The foundational biological sequence of an organism is governed by DNA. Which molecule acts as the intermediary messenger carrying information from DNA to the ribosome?
(A) tRNA
(B) mRNA
(C) rRNA
(D) snRNA

2003

194. Identify the secondary database that exclusively characterizes protein families via Hidden Markov Models (HMMs).
(A) PROSITE
(B) PRINTS
(C) SWISS-PROT
(D) Pfam

2007

195. Which statement accurately describes the sequence composition within GenBank?
(A) It incorporates both coding and non-coding experimentally derived nucleotide sequences
(B) It exclusively contains human sequences
(C) It strictly houses curated 3D protein structures
(D) It filters out all redundant sequences automatically

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2013

251. Which principle explicitly violates the classical Central Dogma of molecular biology?
(A) Transcription of DNA to RNA
(B) Prion-mediated protein-to-protein conformational transfer
(C) Translation of RNA to Protein
(D) Replication of DNA

2013

252. Identify the INCORRECT statement regarding the Protein Data Bank (PDB).
(A) It is the primary worldwide repository for experimentally determined 3D structures
(B) It exclusively houses structures generated purely via computational ab initio predictions
(C) It is managed by the worldwide PDB (wwPDB) consortium
(D) Structures are primarily derived via X-ray crystallography, NMR, and cryo-EM

2003

253. Which parameter mathematically specifies the statistical likelihood that a specific sequence alignment observed in a BLAST search occurred purely by chance?
(A) E-value
(B) Raw score (S)
(C) Bit score ($Sâ€™$)
(D) P-value

2013

254. When generating a PAM substitution matrix, the unit 1 PAM explicitly represents:
(A) 1% absolute sequence identity
(B) 1 gap opening penalty unit
(C) 1 accepted point mutation per 100 amino acids
(D) 1 million years of evolutionary time

2011

255. Consider the following statements regarding structural databases:
I. SCOP classifies proteins manually based on evolutionary relationships.
II. CATH classifies proteins using a semi-automated protocol.
III. PDB strictly stores 2D topological drawings without 3D coordinates.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2015

256. Which of the following defines a "composite" protein database designed to identify functional domains and motifs by searching multiple secondary databases simultaneously?
(A) SWISS-PROT
(B) TrEMBL
(C) InterPro
(D) PDB

2012

257. Which specific sequence alignment tool implements a consistency-based approach, combining pairwise local and global alignment information into a library to guide a highly accurate multiple sequence alignment?
(A) ClustalW
(B) T-Coffee
(C) FASTA
(D) BLASTp

2004

258. What is the explicit computational function of the Neighbor-Joining (NJ) phylogenetic algorithm?
(A) It randomly groups taxa to maximize branch lengths
(B) It utilizes quantum mechanics to predict evolutionary paths
(C) It constructs purely ultrametric trees
(D) It iteratively selects pairs of taxa that minimize the total length of the branches in the tree, producing an unrooted tree

2013

259. What fundamental assumption distinguishes Maximum Likelihood (ML) from Maximum Parsimony (MP) in phylogenetic analysis?
(A) ML utilizes an explicit mathematical model of sequence evolution to calculate the probability of the data, while MP simply minimizes the number of evolutionary changes
(B) ML assumes all mutations are equally probable, while MP uses an explicit statistical model
(C) ML strictly relies on distance matrices
(D) MP requires translated protein sequences

2005

260. Which of the following represents the correct workflow for discovering a novel agrochemical using ligand-based drug design?
1. Construct a 3D pharmacophore model based on shared features
2. Compile a dataset of known structurally

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diverse active compounds
3. Superimpose the active conformations of the dataset
4. Perform virtual screening of a chemical database against the model

(A) 2, 3, 1, 4
(B) 1, 2, 3, 4
(C) 2, 1, 3, 4
(D) 3, 2, 1, 4

2016

261. In transcriptomics, cleaning raw EST reads typically involves removing sequences originating from the cloning vector. What specialized bioinformatics tool or algorithm is classically used for this vector screening?
(A) CrossMatch / Vector NTI
(B) ClustalW
(C) SWISS-MODEL
(D) CoMFA

2019

262. Which thermodynamic scoring function component penalizes the final docking score when a ligand binding pose forces an energetically unfavorable twist in a freely rotatable bond?
(A) Electrostatic interactions
(B) Van der Waals attractive forces
(C) Solvation energy
(D) Internal conformational strain (torsional entropy)

2012

263. In QSAR modeling, collinearity among structural descriptors leads to highly unstable MLR models. Which specific statistical technique addresses this by projecting the data into orthogonal components that maximize covariance with the biological activity?
(A) Random Forests
(B) Partial Least Squares (PLS)
(C) Multiple Linear Regression (MLR)
(D) Support Vector Machines (SVM)

2003

264. Which of the following correctly describes a 1D QSAR descriptor?
(A) Molecular surface area
(B) Dipole moment vector
(C) Total molecular weight (sum of atomic masses)
(D) Spatial coordinates of a pharmacophore

2004

265. Identify the INCORRECT statement regarding the application of Support Vector Machines (SVM) in bioinformatics.
(A) SVM relies on kernel functions (e.g., RBF) to map non-linear data
(B) SVM can be used for both classification (active/inactive) and regression (predicting IC_50)
(C) SVM identifies the optimal hyperplane that maximizes the margin between classes
(D) SVM strictly ignores all descriptor values

2003

266. Which primary nucleotide sequence database is explicitly managed by the National Center for Biotechnology Information (NCBI)?
(A) GenBank
(B) EMBL
(C) DDBJ
(D) PIR

2025

267. What is the fundamental utility of the "Entrez Gene" database within the NCBI ecosystem?
(A) Providing 3D spatial coordinates of crystallized proteins
(B) Acting as a centralized directory consolidating nomenclature, map, sequence, expression, and functional data for individual genes
(C) Storing raw, unannotated genomic sequencing reads
(D) Modeling molecular docking potentials

2007

268. Which biological relationship specifically describes genes in different species that evolved from a common ancestor via a speciation event and typically retain the same biological function?
(A) Paralogs
(B) Orthologs
(C) Xenologs
(D) Analogs

2010

269. The gap penalty mathematical model defined as $W = \gamma + \delta \times (k-1)$, where γ is opening and δ is extension, represents:
(A) An affine gap penalty
(B) A strict linear gap penalty
(C) A zero gap penalty
(D) A dynamic gap penalty

2005

270. The following question consists of two statements—Assertion (A) and Reason (R).

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Answer the question by selecting the appropriate option.

Assertion (A): In multiple sequence alignments, ClustalW automatically applies structural masks to reduce gap penalties in hydrophilic loop regions.

Reason (R): Hydrophilic loops are typically located on the exterior of a protein and are structurally much more tolerant to insertions and deletions than the densely packed hydrophobic core.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

271. Which phylogenetic tree visually depicts an unresolved node where a single ancestral lineage splits into more than two immediate descendant lineages simultaneously?
(A) Dichotomy
(B) Clade
(C) Root
(D) Polytomy

2023

272. In molecular evolution models (e.g., K2P), a "transition" refers to which specific nucleotide substitution?
(A) Purine to Pyrimidine
(B) Pyrimidine to Purine
(C) Purine to Purine or Pyrimidine to Pyrimidine
(D) Adenine to Cytosine

2024

273. The primary transcriptomic bioinformatic resource, dbEST, explicitly archives:
(A) Translated complete proteomes
(B) Short, single-pass reads of cDNA libraries
(C) Whole genome shotgun sequencing assemblies
(D) Curated 3D protein structures

2010

274. Which of the following best characterizes a key operational limitation of rigid-body molecular docking?
(A) It requires quantum mechanical supercomputers for every calculation
(B) It can only dock single atoms
(C) It inherently relies on random guessing without scoring functions
(D) It strictly assumes both the ligand and the target receptor are completely inflexible, ignoring induced-fit phenomena

2013

275. Consider the following statements about QSAR machine learning models:
I. Random Forests use an ensemble of decision trees.
II. ANN architectures feature input, hidden, and output layers.
III. SVM always builds exactly one decision tree.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2010

276. In 3D QSAR, what fundamentally defines the "steric field" calculated at a given grid point during CoMFA analysis?
(A) The Coulombic electrostatic interaction energy
(B) The exact hydrogen bond donor capacity
(C) The Lennard-Jones interaction potential between a standard probe atom (e.g., sp^3 Carbon) and the superimposed ligand
(D) The topological branching index

2015

277. The "central dogma" dictates that genetic information flows from DNA to RNA to Protein. Which specific biological mechanism represents a direct flow from RNA to RNA, commonly seen in specific agricultural viruses?
(A) RNA replication via RNA-dependent RNA polymerase
(B) Reverse transcription
(C) DNA replication via DNA polymerase
(D) Protein translation

2002

278. Which statement correctly identifies a composite structural database that provides pre-calculated structural classifications and functional annotations of PDB entries?
(A) PROSITE
(B) GenBank
(C) EMBL
(D) PDBsum

2022

279. Which parameter of the BLOSUM matrix explicitly dictates the stringency of the alignment clustering?

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(A) The gap opening penalty
(B) The percentage identity threshold used to group sequences in the blocks database (e.g., 62% in BLOSUM62)
(C) The length of the sequences
(D) The size of the k-tuple word

2016

280. Which of the following represents the correct logical progression of steps for performing a multiple sequence alignment using the exact dynamic programming approach?
1. Traceback to construct the alignment
2. Define the N-dimensional scoring matrix and gap penalties
3. Initialize the boundaries of the N-dimensional matrix
4. Fill the matrix with maximum scores

(A) 2, 3, 4, 1
(B) 2, 4, 3, 1
(C) 3, 2, 4, 1
(D) 1, 2, 3, 4

2025

281. In global dynamic programming, the algorithm strictly guarantees:
(A) The highest heuristic search speed
(B) The alignment of only short identical words
(C) The immediate translation into a 3D structural model
(D) The mathematically optimal alignment across the entire lengths of both sequences

2012

282. The term "E-value" in BLAST mathematically estimates:
(A) The expected number of distinct alignments with a score equivalent to or better than the observed score that could occur strictly by chance
(B) The probability that the sequences share no common ancestor
(C) The exact number of identical amino acids in the query
(D) The length of the gap penalty

2023

283. Identify the sequence retrieval system that was heavily utilized in Europe to interlink flat-file biological databases via an advanced parsing index.
(A) BLAST
(B) Sequence Retrieval System (SRS)
(C) Entrez
(D) PDB

2021

284. Which phylogenetic distance metric directly estimates the actual number of evolutionary substitutions that occurred, effectively correcting for multiple substitutions at a single site?
(A) Raw p-distance
(B) Jukes-Cantor distance
(C) Alignment score
(D) Hamming distance

2018

285. In transcriptomics, what explicit molecular feature is utilized to isolate eukaryotic mRNA from total cellular RNA during the construction of a cDNA library?
(A) 3' Poly-A tail
(B) 5' cap
(C) Intron splice sites
(D) Ribosomal binding sites

2023

286. What is the fundamental utility of a consensus scoring approach in molecular docking?
(A) It permanently prevents ligand binding
(B) It relies entirely on random number generation
(C) It averages or combines the scores from multiple distinct scoring functions to reduce false positives and improve predictive accuracy
(D) It rigidly docks the ligand without conformational search

2025

287. Which physicochemical descriptor explicitly models the ratio of a compound's solubility in a hydrophobic solvent (e.g., octanol) versus a hydrophilic solvent (e.g., water)?
(A) Molar refractivity
(B) Dipole moment
(C) Taft steric parameter
(D) Partition coefficient ($LogP$)

2009

288. Which of the following defines the primary mathematical objective of the Partial Least Squares (PLS) algorithm in 3D QSAR?
(A) Free-Wilson analysis
(B) Hansch analysis
(C) Comparative Molecular Similarity Indices Analysis (CoMSIA)
(D) Topological index correlation

2023

289. Identify the INCORRECT pairing regarding machine learning in QSAR.

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(A) ANN - Uses hidden layers and backpropagation
(B) PLS - Unsupervised clustering algorithm requiring no biological activity data
(C) Random Forest - Uses an ensemble of decision trees
(D) SVM - Constructs a separating hyperplane using kernel functions

2011

290. The following question consists of two statements—Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A): Structural alignment is generally considered the "gold standard" over sequence alignment for distantly related proteins.
Reason (R): During evolution, a protein's 3D structure and folding topology are highly conserved to maintain biological function, even when the primary amino acid sequence diverges significantly.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

291. Which database exclusively houses manually annotated, non-redundant, expertly curated protein sequence entries?
(A) SWISS-PROT
(B) TrEMBL
(C) GenBank
(D) ENA

2003

292. In multiple sequence alignment, a "profile" or "Hidden Markov Model" (HMM) specifically represents:
(A) The exact 3D coordinates of the alignment
(B) A strict linear gap penalty
(C) A probabilistic model of sequence conservation at each position in an alignment, factoring in match, mismatch, and gap probabilities
(D) The absolute molecular weight of the sequence

2016

293. Which phylogenetic construction algorithm is explicitly classified as a "distance-based" methodology?
(A) Neighbor-Joining
(B) Maximum Parsimony
(C) Maximum Likelihood
(D) Bayesian Inference

2013

294. What does the branch length mathematically signify in a statistically derived Phylogram?
(A) Nothing; branches are strictly drawn for visual clarity
(B) The precise chronological age in exactly millions of years
(C) The exact size of the organism's genome
(D) The number of evolutionary changes or substitutions per site that have occurred along that branch

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2014

295. Which CADD computational technique explicitly predicts the preferred geometric orientation, translation, and conformation of one molecule to a second when bound to each other to form a stable complex?
(A) Homology modeling
(B) Molecular docking
(C) EST clustering
(D) Pharmacophore extraction

2005

296. The binding affinity predicted by empirical scoring functions in molecular docking is generally calibrated using:
(A) Strict quantum mechanical density functional theory
(B) Only the molecular weights of the compounds
(C) A mathematical regression fit to an experimental dataset of known ligand-receptor binding energies
(D) Random number extrapolation

2018

297. Which of the following describes the function of Partial Least Squares (PLS) in QSAR modeling?
(A) To randomly assign descriptor weights throughout the entire statistical modeling process
(B) To completely ignore molecular structures when predicting the final biological activities
(C) To synthesize novel compounds virtually using a combination of chemical building blocks
(D) To extract latent variables that capture variance in both the 3D fields and the activity

sensitivity and specificity. One particular matrix has become the standard because it was derived from a wide range of conserved protein blocks. This allows it to effectively detect both highly similar and moderately divergent sequences, making it a robust and versatile tool for general-purpose sequence comparison and identification.

44. (B) Shorter parallel diagonal lines running adjacent to the main central diagonal
A self-comparison dot plot provides a unique visual signature for repeated elements within a sequence. When a segment occurs multiple times in the same orientation, it produces diagonal lines that are offset from the central identity line. These parallel diagonals indicate that the sequence contains tandem or interspersed repeats, allowing researchers to quickly identify regions of genomic duplication and structural variation.

45. (A) I, II and IV
Sequence comparison tools offer specialized variants for different research needs. Some compare proteins directly, while others translate nucleotide sequences into their corresponding amino acids before searching. Certain advanced programs even translate both the query and the entire database in multiple reading frames. These tools are essential for identifying genes and finding distant homologs that might be invisible at the nucleotide level.

46. (C) Finding the tree topology that makes the observed sequence data most probable under a specific model
Statistical methods for phylogenetic reconstruction evaluate different tree structures based on their ability to explain the data. This approach uses an explicit model of sequence evolution to calculate the probability of the observed alignment for a given topology. The tree that results in the highest probability is selected as the best estimate of the true evolutionary history of the organisms.

47. (D) T-Coffee
Accuracy in multiple sequence alignment can be improved by combining information from different sources. Some tools use a consistency-based mechanism that builds a library of both local and global pairwise alignments. By ensuring that the final multiple alignment is consistent with the information in this library, the algorithm can achieve higher accuracy, particularly for sequences that are difficult to align.

48. (C) Alternative splicing and sequencing errors can create chimeric or artefactual contigs
Processing expressed sequence tags from complex organisms presents significant computational challenges. The presence of multiple transcript variants from a single gene due to alternative splicing can complicate the assembly process. Additionally, artifacts created during the sequencing process can lead to the formation of incorrect consensus sequences. Successful analysis requires sophisticated algorithms to differentiate true biological variation from experimental noise.

49. (B) To construct optimal hyperplanes in a high-dimensional space to separate active from inactive compounds
Machine learning classification in drug discovery often involves distinguishing between molecules with different biological activities. One sophisticated technique maps molecular descriptors into a high-dimensional space where it can find an optimal boundary. This boundary, or hyperplane, maximizes the distance between the different classes of compounds, providing a powerful and robust method for predicting the activity of new drug candidates.

50. (A) P-2, Q-4, R-3, S-1
Comparing biological sequences involves several distinct metrics to quantify their relationship. One measure focuses on exact matches, while another accounts for chemically similar residues. The overall evolutionary connection derived from a common ancestor is a separate concept. Additionally, alignment algorithms use specific penalties to account for insertions and deletions, ensuring the resulting scores reflect true biological similarity rather than random occurrences.

51. (A) PDB
Three-dimensional structural information is vital for understanding the function of biological macromolecules. A centralized international repository archives the coordinates of proteins, nucleic acids, and complex assemblies determined by experimental methods. This database serves as the foundation for structural biology research, providing the data necessary for molecular modeling, drug design, and the study of

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1. (B) Transcription
Transcription represents the first stage of gene expression in the central dogma of molecular biology. During this specific process, the genetic information encoded within a double-stranded DNA molecule is accurately copied into a complementary single-stranded RNA molecule. This biochemical reaction is catalyzed by RNA polymerase and serves as the essential template for subsequent protein synthesis.

2. (D) Primary databases contain experimental sequence data, whereas secondary ones contain derived motifs and profiles
Bioinformatics databases are fundamentally categorized by their data origin. Primary repositories archive raw, unedited experimental sequences directly submitted by researchers worldwide. In contrast, secondary databases add value by processing this raw information to identify highly conserved functional motifs, protein domains, and evolutionary profiles. This differentiation ensures researchers can access both original experimental evidence and curated analysis.

3. (A) Protein Information Resource (PIR)
The International Nucleotide Sequence Database Collaboration consists of three major global repositories: GenBank, the European Nucleotide Archive, and the DNA Data Bank of Japan. These organizations synchronize their data daily to provide a comprehensive resource for nucleotide sequences. The Protein Information Resource, however, focuses on protein sequences and is not a formal member of this specific nucleotide collaboration.

4. (C) SWISS-PROT is manually annotated and reviewed, while TrEMBL is computer-annotated and unreviewed
The UniProt Knowledgebase maintains two distinct sections with different levels of review and documentation. The first section contains manually annotated records based on experimental evidence and literature, ensuring high reliability. The second section consists of computer-annotated entries that have not yet been reviewed by experts. This division allows for both high-quality data and comprehensive coverage.

5. (A) It stores spatial coordinates of atoms along with HEADER, ATOM, and HETATM records
Macromolecular structures are described using specific file formats that provide detailed atomic information. The standard format includes metadata in the header and precise three-dimensional spatial coordinates for every atom in the molecule. It distinguishes between standard residues and non-standard groups like ligands or water molecules, allowing researchers to visualize and analyze complex biological structures with high precision.

6. (D) An integrated information retrieval system for interconnected databases
Modern biological research requires access to diverse data types stored across multiple specialized repositories. An integrated retrieval system allows users to search across these platforms simultaneously using unified queries. By interlinking sequences, structures, literature, and genomic maps, this system facilitates comprehensive data discovery and enables researchers to identify complex biological relationships that would remain hidden in isolated databases.

7. (B) Orthologs
Molecular evolution results in different types of homologous genes depending on the nature of their divergence. When a single ancestral gene is separated into different lineages through a speciation event, the resulting genes are categorized as orthologs. These genes typically maintain the same biological function across different organisms, providing a critical foundation for comparative genomics and functional annotation.

8. (C) It reflects the reality that a single mutational event can insert or delete a block of multiple residues
Natural evolutionary processes often involve the insertion or deletion of multiple adjacent residues in a single mutational event. An affine scoring model accounts for this by applying a

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2001

298. Identify the specific type of machine learning applied when predicting a continuous biological activity value (e.g., $IC_{50} = 45\mu M$) using QSAR descriptors.
(A) Regression
(B) Unsupervised clustering
(C) Classification
(D) Dimensionality reduction

2008

299. In agricultural bioinformatics, predicting an effective pesticide's toxicity requires understanding its steric bulk. Which parameter explicitly quantifies the volume occupied by an atom or functional group in 2D QSAR?
(A) Partition coefficient
(B) Molar refractivity
(C) $LogD$
(D) Dipole moment

2005

300. Which open-source, flexible, command-line tool suite is widely utilized in the bioinformatics ecosystem specifically for analyzing, converting, and processing high-throughput sequence data formats?
(A) ChemDraw
(B) EMBOSS
(C) AutoDock Vina
(D) PyMOL

****

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that requires the absolute minimum number of evolutionary changes to explain the observed data across all the aligned characters.

18. (D) To group redundant overlapping ESTs into continuous unique contiguous sequences known as consensus contigs
Transcriptomic data often contain numerous short, redundant sequence fragments representing different parts of the same gene. Clustering these fragments allows researchers to collapse overlapping reads into a single representative sequence. This process reduces data complexity and enables the assembly of longer, more complete transcripts, which is essential for accurate gene identification and functional characterization in various biological studies.

19. (A) Must be distributed under identical open-source license terms
The GNU General Public License utilizes a copyleft mechanism to ensure that software remains freely available to the community. This legal condition mandates that any modifications or derivative works based on the original code must also be released under the same open-source terms. This policy prevents the privatization of community-developed tools and fosters transparency and collaboration in bioinformatics research.

20. (A) P-4, Q-1, R-3, S-2
Computational drug discovery utilizes various strategies depending on the available data. Ligand-based methods rely on known active molecules, while structure-based approaches utilize the three-dimensional coordinates of the target protein. Pharmacophore modeling defines the essential features for interaction, and molecular docking predicts how a ligand fits into a binding site, allowing for the precise estimation of binding orientations.

21. (A) Solvation/desolvation entropy
The binding of a small molecule to a protein receptor is a thermodynamic process influenced by the surrounding solvent. As the ligand enters a hydrophobic pocket, ordered water molecules are released back into the bulk solvent. This increase in entropy provides a significant driving force for binding and must be accounted for in scoring functions to accurately predict affinity.

22. (D) Lipophilicity/hydrophobicity
Quantitative modeling of drug activity requires descriptors that reflect the physical properties of molecules. The partition coefficient measures how a compound distributes between water and an organic solvent, typically octanol. This value provides a critical estimate of the molecule's ability to cross biological membranes and interact with hydrophobic regions of proteins, making it essential for predicting pharmacokinetic behavior.

23. (B) Steric and electrostatic fields
Three-dimensional quantitative structure-activity relationship models analyze how the spatial properties of ligands correlate with their biological activity. By placing molecules on a grid, the algorithm calculates interaction energies based on shape and charge distribution. These two primary fields characterize the volume occupied by the molecule and its potential for ionic or polar interactions, allowing for the design of more potent inhibitors.

24. (C) Random Forests
Machine learning techniques are increasingly used to build robust predictive models for drug discovery. By constructing a large ensemble of individual decision trees and averaging their outputs, this specific method improves prediction accuracy and significantly reduces the risk of overfitting. This approach is highly effective for handling complex biological datasets with numerous descriptors and non-linear relationships between structure and activity.

25. (C) IV only
Biological databases are diverse and cater to various research needs. Primary databases store raw data, while secondary and composite databases provide processed and integrated information. Although structural databases are well-known for protein coordinates, they also archive significant amounts of data for nucleic acids and their complexes. Therefore, claiming that these repositories lack information for nucleic acids is biologically and technically incorrect.

26. (A) It integrates flat-file indexing across diverse, disparate biological databases
Accessing biological information often involves searching across multiple specialized platforms that store data in different formats. An integrated

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retrieval architecture solves this by creating a unified index of flat-file records from various sources. This allows researchers to perform complex cross-database queries through a single interface, significantly streamlining the data retrieval process and facilitating the discovery of interconnected biological information.

27. (B) Gap opening penalty - Penalty for initiating a gap in the alignment
Pairwise sequence alignment requires specific parameters to account for mutational events. When the algorithm introduces a break in a sequence to maximize matches elsewhere, it applies a specific cost known as a gap opening penalty. This parameter prevents the excessive introduction of gaps, ensuring that the resulting alignment reflects biologically plausible evolutionary relationships rather than coincidental matches between unrelated residues.

28. (B) BLOSUM is based on observed frequencies in local alignments of conserved protein blocks
Substitution matrices are derived using different methodologies and evolutionary assumptions. One series is built from global alignments and extrapolated over time, while the other is constructed directly from local alignments of highly conserved protein segments. By focusing on these blocks, the latter approach provides a more empirical representation of conserved functional motifs, making it highly effective for database searching.

29. (A) Identifying conserved functional domains within otherwise divergent protein sequences
Local alignment algorithms are essential for detecting shared regions of similarity between sequences that are otherwise different. By focusing on finding the highest-scoring local segment rather than force-aligning the entire length, this method can identify conserved domains or motifs. This is particularly useful for studying multidomain proteins that share specific functional units despite having different evolutionary histories or overall structures.

30. (A) 2, 3, 1, 4
Rapid database searching utilizes a heuristic approach to find similarities efficiently. The process begins by generating a list of high-scoring short words from the query. The database is then scanned for exact matches to these words, which serve as seeds. These seeds are extended into longer segments to calculate scores and determine the statistical significance of the resulting alignments.

31. (D) A column containing identical or chemically similar amino acids across all species
Conservation patterns in multiple sequence alignments reveal critical functional and structural regions. When a specific position in the alignment contains the same or similar residues across many divergent species, it indicates that the position is under strong evolutionary pressure. Such invariant columns typically highlight active sites of enzymes or residues essential for the stability and folding of the protein.

32. (C) The hypothetical most recent common ancestor of all entities in the tree
Evolutionary relationships are visually represented using trees that track the divergence of lineages over time. A rooted tree includes a specific point that represents the origin of the entire group being studied. This node signifies the common ancestor from which all other organisms in the tree have descended, providing directionality to the evolutionary process and allowing for relative dating.

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33. (B) A strict molecular clock with a constant substitution rate
Certain phylogenetic methods rely on specific assumptions about the speed of molecular change. One such approach assumes that mutations accumulate at a constant rate across all lineages in the tree. This molecular clock hypothesis results in an ultrametric tree where all tips are equidistant from the root, providing a simple but often restrictive model for estimating evolutionary timelines and relationships.

34. (D) A cDNA library represents only transcribed genes of a cell type, lacking introns and regulatory regions
Genomic libraries contain the entire DNA content of an organism, including all coding and non-coding sequences. In contrast, libraries created from messenger RNA only include the sequences that are actually expressed as proteins in a specific cell. Because these sequences are processed to remove non-coding segments, they provide a focused view of the functional genome and are essential for expression studies.

35. (A) I, II and IV
Computer-aided drug design involves several complex methodologies to predict molecular interactions. Docking simulations explore how ligands fit into receptor sites, while three-dimensional quantitative modeling requires precise structural alignment of the molecules being studied. Advanced techniques like CoMSIA improve these models by calculating multiple interaction fields, including hydrophobic and hydrogen-bonding potentials, allowing for a more detailed characterization of molecular recognition.

36. (C) Empirical scoring functions
Predicting binding affinity in molecular docking requires mathematical functions that estimate interaction energy. One approach utilizes parameters derived from a large dataset of known protein-ligand complexes with experimentally determined binding constants. By fitting these parameters to match observed data, the function can rapidly estimate the affinity of new compounds based on their geometric and chemical features within the binding pocket.

37. (A) By utilizing a distance-dependent Gaussian function to avoid singularities at atomic centers
Traditional field-based QSAR methods often suffer from mathematical issues where interaction energies become infinite when a probe atom overlaps with the molecule. An improved methodology addresses this by using a smooth Gaussian function to calculate fields. This approach eliminates sharp changes in energy near atomic centers and produces more stable models that are less sensitive to small variations in molecular alignment.

38. (D) ANNs are highly resistant to overfitting, eliminating the need for validation datasets
Artificial neural networks are powerful tools for modeling complex biological data through interconnected layers of nodes. These systems are trained by adjusting weights to minimize errors between predicted and observed values. However, they are prone to capturing noise in the data, making them susceptible to overfitting. Consequently, rigorous validation using independent datasets is essential to ensure the model's predictive reliability.

39. (B) PIR
Primary biological databases serve as central archives for direct experimental results submitted by researchers. While many databases focus on motifs or specific protein families, one major repository was established specifically to store and organize protein sequence data. Historically organized by superfamilies, this resource provides a comprehensive collection of protein sequences and served as a founding member of the unified international protein consortium.

40. (A) Both A and R are true and R is the correct explanation of A.
Global alignment algorithms are designed to compare two sequences from end to end, which requires incorporating the entire length of both into the final result. This approach becomes problematic when sequences have different lengths or share only a small functional unit. The algorithm applies penalties to unaligned regions at the ends, which can obscure the signal from the conserved domain.

41. (D) Speciation leading to functional divergence or conservation in separate lineages
The classification of homologous genes depends on the evolutionary event that caused their separation. Orthologs are defined as genes in different species that originated from a single gene in a common ancestor and were separated when the lineages diverged. Because they typically retain the same function, these genes are the primary focus of comparative studies and evolutionary reconstructions across species.

42. (A) Polymerase slippage or unequal crossing over often inserts or deletes multiple adjacent residues in a single event
Biological evidence suggests that insertions and deletions often occur as blocks of residues rather than individual events. This is due to mechanisms like strand slippage during replication or unequal recombination. To reflect this reality, alignment algorithms use a specific penalty model that makes it easier to extend an existing gap than to start a new one, producing more accurate biological alignments.

43. (B) It balances the detection of closely related and moderately distant homologous proteins empirically
Choosing a default scoring matrix for protein database searches requires a balance between

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higher cost to initiate a gap and a lower cost to extend it. This mathematical approach produces more biologically realistic alignments compared to models that penalize every gap position identically.

9. (D) PAM250
The Point Accepted Mutation matrix series is based on an evolutionary model where higher numbers correspond to greater divergence. Each unit represents a specific amount of mutation over time. Consequently, matrices with larger values are specifically designed to detect distant relationships between proteins that have undergone significant changes, whereas lower-numbered matrices are optimized for comparing closely related sequence pairs.

10. (A) Both A and R are true and R is the correct explanation of A.
Visualizing sequence similarities through a dot plot allows for the rapid identification of complex genomic features. When a sequence is compared against itself, the presence of identical segments at different positions results in diagonal lines that are parallel to the main identity diagonal. This graphical pattern clearly indicates the presence and location of direct repeats within the query sequence.

11. (B) Global dynamic programming
Mathematically optimal alignments of two sequences across their entire lengths are achieved using global dynamic programming. This algorithmic approach systematically builds a scoring matrix by evaluating matches, mismatches, and gaps for every possible position. By considering all possible paths from the beginning to the end of the sequences, it ensures that the final result represents the best possible global alignment.

12. (B) The number of alignments with a given score expected to occur by chance in a database search
Determining the biological significance of a sequence match requires statistical evaluation. The expectation value quantifies how many times an alignment with a specific score is likely to appear in a database search purely by random chance. A very low value suggests that the similarity is due to a common evolutionary origin rather than a coincidental match of residues.

13. (A) blastx
Comparing a DNA sequence against a protein database requires the translation of the nucleotide query. This specific search program automatically converts the query into all six possible reading frames and compares the resulting protein sequences against the database. This approach is highly effective for identifying protein-coding genes in genomic sequences and for characterizing unannotated DNA segments with high sensitivity.

14. (C) Iterative alignment
Traditional progressive methods for multiple sequence alignment often suffer from early errors that cannot be corrected as more sequences are added. To solve this, iterative approaches repeatedly refine the initial alignment by recalculating subgroups of sequences. This process allows the algorithm to optimize the overall score and correct misaligned gaps, leading to a more accurate representation of homology.

15. (B) I and III
Progressive multiple sequence alignment tools utilize a specific workflow to handle multiple datasets efficiently. They first calculate a distance matrix from pairwise comparisons to build a guide tree, which then determines the order of sequence addition. While this heuristic approach is computationally fast and effective for large datasets, it does not guarantee a mathematically optimal global solution for all sequences.

16. (C) A group of organisms consisting of a single common ancestor and all its descendants
Phylogenetic trees are organized into specific evolutionary groups that reflect their shared ancestry. A monophyletic group, commonly known as a clade, includes a specific ancestral lineage and every descendant that has evolved from it. Identifying these groups is fundamental to taxonomy and molecular phylogeny, as it allows researchers to accurately classify organisms based on their true evolutionary history.

17. (B) Maximum Parsimony
Phylogenetic construction methods are broadly classified into distance-based and character-based approaches. While distance methods reduce sequences to a single numerical value of difference, character-based methods analyze every site in the alignment directly. The parsimony approach seeks the tree topology

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fundamental biological processes at the atomic level.

52. (C) PDB format
Storing the three-dimensional structures of biological molecules requires a specialized and highly organized text-based format. This system uses fixed-width columns to provide detailed information for every atom, including its name, residue type, chain identifier, and precise spatial coordinates. This structured arrangement allows software programs to easily parse and visualize complex molecular geometries, facilitating detailed structural analysis and computational simulations.

53. (A) Nodes
Phylogenetic trees are composed of several structural elements that represent evolutionary history. The points where a single branch divides into two or more descendant lineages are known as nodes. These nodes signify common ancestors and represent divergence events in the tree. Understanding the arrangement of these internal points is essential for interpreting the branching patterns and evolutionary relationships between organisms.

54. (D) NJ is computationally much faster and efficiently handles large numbers of taxa
Constructing phylogenetic trees for thousands of sequences requires highly efficient algorithms. While some methods evaluate all possible tree shapes, which is computationally expensive, others use a simpler approach based on distance matrices. This decomposition method builds the tree by sequentially joining the most similar pairs, making it much faster and more suitable for analyzing large datasets in a reasonable timeframe.

55. (B) Housing collections of short, single-pass sequence reads from mRNA transcripts
Transcriptomics research produces large volumes of short sequence fragments that represent the expressed genes of a cell. A specialized division of the national nucleotide database was created to archive these single-pass reads. This resource is invaluable for gene discovery, mapping transcripts to genomes, and identifying tissue-specific expression patterns, providing a snapshot of the functional state of an organism.

56. (C) Free and Open-Source Software (FOSS)
The development of bioinformatics tools often relies on a philosophy that promotes collaborative research and transparency. Certain licensing models guarantee that users have the right to access the source code, modify it for their own needs, and share the software with others. This approach ensures that scientific tools remain accessible to the entire community, fostering innovation and reproducible research practices.

57. (D) The 3D high-resolution structure of the biological target receptor
Designing new drugs using structural information requires precise knowledge of the target's physical shape. Before computational screening can begin, researchers must obtain the three-dimensional coordinates of the receptor, typically through experimental methods like X-ray crystallography. This structure defines the binding site's geometry and chemical environment, which are essential for predicting how potential drug molecules will interact with the target.

58. (A) Induced-fit docking allows strictly the ligand to flex while keeping the receptor rigidly fixed
Molecular docking simulations use different levels of complexity to model binding events. The simplest approach treats both molecules as rigid, while more advanced methods allow the ligand to change its shape. The most realistic model accounts for the mutual adjustment of both the ligand and the receptor's active site upon binding, reflecting the dynamic nature of biological molecular recognition.

59. (B) Multiple Linear Regression (MLR)
Developing mathematical models to predict biological activity involves correlating structural properties with observed effects. A common statistical approach uses several independent variables, representing different molecular descriptors, to explain the variation in a single dependent variable, such as drug potency. This method provides a clear equation that relates the physical and chemical features of a molecule directly to its biological performance.

60. (A) 2, 3, 4, 1
Computational docking follows a logical series of steps to ensure accurate results. The process starts with preparing the protein structure, followed by defining the specific region where

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binding occurs. The algorithm then explores many different ways the ligand can fit into that site. Finally, these poses are evaluated and ranked based on their predicted energy to identify the most likely binding mode.

61. (A) CATH
Organizing the vast space of protein structures requires hierarchical classification systems. One major resource categorizes proteins based on their overall shape and evolutionary connections. It uses a specific four-level system that tracks the class of secondary structures, the general architecture, the specific folding topology, and the homologous superfamily, allowing researchers to explore the structural and functional relationships between different proteins.

62. (C) SRS (Sequence Retrieval System)
Efficiently searching multiple biological databases requires a unified interface that can handle diverse data formats. One major retrieval system became the standard in Europe for its ability to index flat-file records and provide extensive cross-referencing between different sources. This allowed users to navigate easily between sequences, structures, and functional data, serving as a powerful counterpart to other major international search platforms.

63. (D) Share only a short conserved domain but are otherwise highly divergent from each other
Sequence comparison methods must be chosen based on the expected relationship between the molecules. If two sequences are only similar in a small region, such as a functional domain or a binding motif, a global alignment will fail to capture the signal due to the surrounding noise. In these cases, a local approach is necessary to identify and align only the conserved segments.

64. (C) It begins with a greater-than symbol (>) followed by a description line, with sequence data on subsequent lines
Bioinformatics tools require standardized file formats for exchanging sequence information. One of the most widely used formats is characterized by its simplicity and ease of parsing. It consists of a single header line that starts with a specific symbol and contains a description of the sequence, followed by the raw sequence data. This format supports both nucleotide and protein sequences.

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65. (B) I and III
Substitution matrices used in sequence alignment are built on specific evolutionary models. Some are derived by observing mutations in closely related proteins and extrapolating those frequencies over longer time periods. One such matrix uses a model where a specific number of mutations occur per hundred residues, providing a way to score alignments between sequences that have diverged significantly over evolutionary time.

66. (D) The match is virtually identical, and the probability of it occurring by chance is practically zero
The statistical significance of a database search result is measured by its expectation value. When this value reaches zero, it indicates that the number of similar alignments expected to occur by random chance is effectively non-existent. This suggests that the two sequences are nearly identical and share a very recent common ancestor, providing high confidence in the biological relevance of the match.

67. (A) Errors made in the early stages of alignment are propagated and cannot be corrected later
Progressive alignment is a common strategy for handling multiple sequences by building the alignment in steps. It starts with the most similar pairs and gradually adds more distant sequences based on a guide tree. However, this approach is limited because once a gap is introduced in an early step, it remains fixed throughout the rest of the process, potentially leading to errors.

68. (C) Outgroup
Establishing the direction of evolutionary change in a phylogenetic tree requires a reference point. Researchers include a taxon that is known to be less closely related to the group of interest than the members of that group are to each other. This reference allows the tree to be rooted, clarifying which character states are ancestral and which are newly derived.

69. (A) General Time Reversible (GTR)
Accurate phylogenetic modeling requires substitution models that account for the complexity of molecular change. The most comprehensive models allow for different rates between all possible types of nucleotide changes and recognize that the four bases do not occur with equal frequency. This level of detail provides

a more realistic representation of evolution, leading to more accurate tree topologies and branch lengths.

70. (A) Both A and R are true and R is the correct explanation of A.
Producing eukaryotic proteins in bacterial hosts presents a significant challenge because bacteria lack the machinery to process complex gene structures. Eukaryotic genes contain non-coding regions that must be removed to create a functional protein. Because bacteria cannot perform this splicing, researchers must use DNA copies of the processed messenger RNA, which only contain the necessary coding information for translation.

71. (B) A specific spatial arrangement of steric and electronic features necessary for optimal supramolecular interactions with a specific biological target
In drug design, a pharmacophore represents the core molecular blueprint required for biological activity. It is not a physical molecule but rather a geometric description of the essential features, such as charges and hydrophobic regions, that allow a ligand to bind to its target. This model is used to screen chemical databases for new compounds that share these critical interaction characteristics.

72. (C) CoMFA
Analyzing the relationship between structure and activity often involves calculating the interaction energy between a ligand and a probe at various points in space. By placing molecules on a three-dimensional grid, the algorithm can measure potentials related to shape and electrostatic charge. These values are then used in statistical models to identify which regions of the molecule are most important for potency.

73. (D) A majority vote among an ensemble of independent decision trees
Ensemble learning methods improve prediction stability by combining the results of many individual models. One popular technique builds multiple decision trees using random subsets of the data and the features. When making a final prediction, the algorithm aggregates the results from all these trees, typically through a voting process. This approach is highly effective at handling noise and preventing overfitting.

74. (A) Wiener index
Molecular descriptors are numerical values that represent specific features of a chemical structure. Some descriptors focus on the connectivity of atoms without considering three-dimensional geometry. These topological indices are calculated from the molecular graph and reflect properties like branching and size. One classic example measures the total distance between all pairs of atoms, providing a simple but effective way to characterize molecular structure.

75. (B) II and III
Major biological databases are maintained by specific international organizations that collaborate to share data. While some focus on sequence information, others archive structural coordinates determined through experimentation. It is important to distinguish between the organizations that manage these resources and the types of data they contain, as well as the difference between experimentally derived structures and those generated through computational modeling.

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76. (A) To integrate predictive models, protein signatures, and motifs from multiple databases into a single searchable resource
Protein families and domains are characterized using many different methodologies across various specialized databases. To simplify the search process, a composite resource was developed that integrates these different signatures into a single interface. By combining information from multiple sources, this tool provides a more comprehensive and reliable classification of protein function and evolution, which is essential for large-scale genomic studies.

77. (A) Orthologs arise via speciation and typically retain similar function, while paralogs arise via gene duplication and often evolve new functions
Homologous genes are distinguished by the evolutionary events that created them. Genes in different species that diverged through speciation often maintain their original biological role. In contrast, genes that originate from duplication within a single genome are free to evolve new functions because the original copy still performs the necessary tasks. This distinction is fundamental to understanding gene family evolution and function.

95. (B) P-2, Q-1, R-4, S-3
Bioinformatics involves several specialized databases that store different categories of biological information. Some repositories focus on nucleotide sequences, while others provide highly annotated protein data or three-dimensional structural coordinates. Additionally, some databases characterize protein families and functional sites using motifs and patterns. Knowing the primary data type of each resource is essential for navigating the complex landscape of biological information and performing accurate research.

96. (C) PIR was historically organized into superfamilies and aligned families, which later contributed to the unified UniProt consortium
The history of protein databases shows how different organizational philosophies have evolved over time. One early resource focused on grouping proteins into superfamilies based on their evolutionary connections. This systematic classification provided a strong foundation for understanding protein relationships. Eventually, this repository joined forces with other major international databases to create a unified resource that integrates manual annotation with comprehensive sequence coverage for all known proteins.

97. (B) It delineates non-standard groups, such as ligands, cofactors, and bound water molecules
Structural files for macromolecules must account for all components present in the experimental sample. While standard residues have specific records, other molecules like drugs, ions, or water are identified using a different record type. This distinction allows software to differentiate between the main protein or nucleic acid chain and the small molecules that may be interacting with it, which is critical for studying binding events.

98. (D) Entrez
A centralized retrieval system at the National Center for Biotechnology Information allows users to perform complex searches across many different databases. By using logical operators, researchers can combine terms to refine their queries, ensuring they find the most relevant sequences, papers, and structural data. This interconnected architecture makes it easy to navigate between different types of biological information through a single, powerful search interface.

99. (A) The ratio of identical amino acid/nucleotide residues aligned exactly in the same column
Quantifying the relationship between two biological sequences involves measuring how many positions share the exact same character. This identity score is calculated by dividing the number of identical residues by the total length of the alignment. While it provides a simple and clear measure of similarity, it does not account for chemically similar residues that might still preserve the protein's overall function and structure.

100. (A) P-1, Q-4, R-3, S-2
Evolutionary relationships between genes are categorized based on their origins. Homology is the general term for shared ancestry, which can arise through different events. Speciation creates genes in separate lineages, while duplication creates multiple copies within the same genome. Additionally, some genes may develop similar functions independently without sharing a common ancestor. Correctly identifying these relationships is essential for understanding gene evolution and function across species.

101. (A) PAM matrix
Substitution matrices are used to score sequence alignments based on the probability of residues changing over time. One common series is derived from an evolutionary model that tracks point mutations. The scores in these matrices represent the log-odds ratio of how often a mutation is observed compared to what would be expected by chance. This allows for the statistical evaluation of the similarity between divergent protein sequences.

102. (D) An inverted repeat or palindromic sequence
Dot plots are powerful visual tools for identifying patterns within a single sequence. When a segment is compared against its own reverse complement, specific graphical features appear. A line that runs perpendicular to the main identity diagonal indicates the presence of a sequence that reads the same in both directions, highlighting regions of self-complementarity or inverted repeats that are often structurally significant in biology.

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a measure of how well the data supports each clade.

87. (B) Messenger RNA (mRNA)
Studying the functional parts of the genome requires focusing on the sequences that are actually transcribed. In transcriptomics, researchers isolate the molecules that carry genetic information to the ribosomes. These transcripts are then converted into stable DNA copies, which provide the raw material for sequencing and gene expression analysis. This approach allows for the identification of active genes in specific tissues or conditions.

88. (C) It facilitates transparent, reproducible research and community-driven methodology enhancements
The use of open-source software in biological research offers several significant benefits. Because the source code is freely available, other scientists can inspect the algorithms, identify errors, and suggest improvements. This transparency fosters a collaborative environment where methods can be independently verified, leading to more robust and reproducible scientific results. It also allows for rapid adaptation of tools to new research challenges in agriculture.

89. (D) Structurally similar molecules tend to exhibit similar biological activities and bind to the same targets
Ligand-based drug discovery is built on a fundamental observation in medicinal chemistry regarding molecular similarity. It assumes that compounds with similar shapes and chemical features are likely to interact with biological targets in the same way. By identifying the common properties of known active molecules, researchers can design new drug candidates that are likely to possess similar biological effects, even without knowing the structure of the receptor.

90. (A) Both A and R are true and R is the correct explanation of A.
Calculating interaction energies during molecular docking can be very time-consuming. To speed up the process, the potential fields of the receptor are pre-calculated and stored on a three-dimensional grid. During the ligand search, the algorithm simply looks up these pre-calculated values instead of performing complex atomic calculations at every step. This grid-based approach significantly reduces the computational effort required for large-scale docking studies.

91. (B) Molar refractivity
Quantitative modeling of molecular interactions requires descriptors that capture different physical properties. One important parameter measures the polarizability of a compound and is directly related to its atomic volume. This value serves as a measure of the steric bulk of a molecule, providing information about its size and how it might fit into a protein's binding site, which is essential for predicting potency.

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92. (B) Interaction field descriptors are exquisitely sensitive to the precise 3D spatial alignment and superimposition of the ligand set
Field-based QSAR models rely on comparing the interaction energies of different molecules at the same points in space. If the molecules are not perfectly aligned, the calculated fields will not represent the same structural regions, leading to inaccurate models. Therefore, identifying a common orientation and superimposing the ligands accurately is the most critical step in building a reliable three-dimensional quantitative model of biological activity.

93. (A) MLR handles collinear descriptors poorly, whereas PLS reduces them into orthogonal latent variables
Statistical modeling in drug design often involves many molecular descriptors that are highly correlated with each other. This collinearity can cause traditional regression methods to become unstable and unreliable. An advanced regression technique solves this problem by transforming the original descriptors into a smaller set of independent components. These components capture the maximum information from the data, providing more robust and predictive models for biological activity.

94. (C) Reverse transcriptase
The classical central dogma was originally described as a unidirectional flow of genetic information. However, the discovery of a specific enzyme changed this view by demonstrating that information could also flow in the opposite direction. This enzyme is capable of synthesizing a DNA molecule from an RNA template, a process essential for the life cycle of certain viruses and the creation of complementary DNA libraries in research.

all improvements and modifications remain freely available to everyone, preventing the privatization of tools developed for the public good.

112. (C) It completely ignores the steric hindrance of the receptor pocket
Designing drugs based on the three-dimensional structure of a target requires a detailed understanding of how molecules fit together. The binding site has a specific shape and chemical environment that limits which molecules can bind. Algorithms evaluate potential drug candidates by simulating how they fit into this pocket, carefully considering both attractive interactions and the physical repulsion caused by overlapping atoms, which is essential for accurate binding predictions.

113. (B) The conformational adjustment of both the ligand and the active site of the receptor to optimize binding interactions
Molecular recognition is a dynamic process where both the binding molecule and the receptor can change their shapes. As a ligand approaches the active site, it triggers conformational shifts in the protein that allow for a better fit and stronger interactions. This mutual adjustment, often described as a hand-in-glove fit, is essential for the function of many enzymes and receptors and must be modeled in advanced docking simulations.

114. (D) Electronic descriptors
The biological activity of a drug is often influenced by how its charges are distributed. Numerical values that represent properties like dipole moments and atomic charges are used in quantitative models to understand these effects. These descriptors reflect the molecule's potential for forming polar bonds and interacting with the electric fields of the target protein, providing critical information for optimizing the potency and specificity of new drug candidates.

115. (B) I and III
Computer-aided drug design uses different strategies depending on what is known about the biological system. If the receptor structure is available, researchers can simulate docking. If only active molecules are known, they can build a geometric model of the essential binding features. Advanced quantitative models combine these ideas by calculating multiple interaction fields on a grid, allowing for a detailed analysis of how molecular structure relates to biological activity.

116. (C) Artificial Neural Networks (ANN)
Modeling the complex relationships between chemical structure and biological activity often requires advanced computational methods. One approach uses a system inspired by the human brain, consisting of interconnected layers that process information. These models are particularly good at identifying non-linear patterns in the data, making them highly effective for predicting the potency and toxicity of new drug candidates when traditional linear regression methods are insufficient for the task.

117. (A) DDBJ
Global efforts to archive nucleotide sequence data involve three major international organizations that share information daily. One of these repositories is based in Japan and serves as a primary hub for researchers in the region and worldwide. This database provides a comprehensive collection of genetic information and participates in the development of standardized tools and formats for the bioinformatics community, ensuring that sequence data remains accessible to all.

118. (D) It integrates and cross-references data from multiple primary and secondary databases into a single interface
Navigating the diverse landscape of biological information can be challenging due to the large number of specialized repositories. A specific type of database solves this problem by collecting and organizing data from many different sources into a unified system. By providing extensive links between sequences, structures, and functions, these integrated platforms allow researchers to perform comprehensive queries and discover complex relationships across various types of biological data.

119. (B) Manual curation, literature review, and expert annotation
The quality of protein sequence data is ensured through a rigorous review process. While most entries are initially generated by automated systems, a subset of the data undergoes extensive manual checking. Experts review the available literature and experimental evidence to provide high-quality functional annotations. This process

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103. (B) Negative scoring cells are reset to zero
Local alignment algorithms are designed to find the best matching regions between sequences, even if they are very different overall. The mathematical key to this approach is preventing the cumulative score from becoming negative. By resetting any negative value in the scoring matrix to zero, the algorithm can effectively start a new alignment at any position, ensuring it captures only the most significant local similarities.

104. (C) blastn uses a larger word size (typically $W = 11$ or 28) because DNA alphabet is smaller, while blastp uses a smaller word size ($W = 3$)
Rapid database searching relies on initial short matches to identify potential alignments. The size of these matches, known as the word size, is chosen based on the alphabet of the sequences being searched. Because the DNA alphabet has only four characters, a larger word is needed to ensure the initial matches are not purely random. Proteins have twenty amino acids, allowing for much smaller word sizes to be used effectively.

105. (A) Both A and R are true and R is the correct explanation of A.
Progressive multiple sequence alignment is a heuristic approach that builds an alignment by following a specific order. This order is determined by a guide tree based on pairwise similarities. However, this method is susceptible to errors because any mistakes made during the alignment of the first, most similar sequences are permanently fixed and will influence the rest of the alignment process as more distant sequences are added.

106. (A) To down-weight highly similar sequences and up-weight divergent ones, preventing overrepresentation of a specific clade
Multiple sequence alignments can be biased if the input data contains many highly similar sequences from the same group. To ensure that the alignment accurately reflects the full range of evolutionary diversity, algorithms apply a weighting system. This process adjusts the contribution of each sequence, reducing the influence of redundant pairs and giving more weight to divergent sequences, which results in a more balanced and representative alignment.

107. (B) Paraphyletic
Evolutionary groups are defined by their relationship to a common ancestor. A group that includes the ancestor but leaves out some of its descendant lineages is known as paraphyletic. This classification is often used in traditional taxonomy but is considered incomplete in modern cladistics, which prefers monophyletic groups that include every descendant of a specific ancestor to accurately reflect the true branching patterns of evolution.

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108. (B) Neighbor-Joining (NJ)
Certain phylogenetic methods are more flexible than others regarding the speed of molecular change. While some assume a constant rate across all lineages, others allow different branches to evolve at different speeds. One popular distance-based algorithm uses a specific clustering strategy to minimize the total tree length without requiring a strict molecular clock, making it suitable for a wide range of biological datasets with varying evolutionary rates.

109. (A) Contig assembly
After raw transcript sequences have been processed and grouped based on their similarities, the next step is to combine the overlapping fragments. This computational process aligns the individual reads to create a single, continuous consensus sequence that represents a much larger portion of the original transcript. These assembled sequences are then used for gene identification and functional analysis, providing a clearer picture of the transcriptome.

110. (A) 2, 4, 3, 1
Protein structure is organized into a specific hierarchy of complexity. The sequence of amino acids forms the primary foundation, which then folds into regular patterns like helices and sheets. These elements further arrange themselves into a final three-dimensional shape. Finally, multiple folded chains can assemble together into a larger functional complex. Understanding these levels is essential for studying how proteins function and interact within the cell.

111. (D) The right to monopolize and close the source code of derivative works
Open-source licensing is designed to protect the collective freedom of the software community. It guarantees that anyone can run the program, study its code, and redistribute it. However, it also includes a specific requirement that prevents anyone from turning the software into a closed-source product. This ensures that

representation of evolutionary history. This character-based method is widely used for its clear logical foundation and ability to analyze every site directly.

128. (C) Similar traits evolved independently (convergence) or resulting from reversals, rather than common ancestry
Interpreting evolutionary history can be complicated by traits that look similar but have different origins. In some cases, organisms may develop similar features independently because they live in similar environments, a process known as convergent evolution. In other cases, a trait may be lost and then regained. These misleading similarities are not due to shared ancestry and must be carefully distinguished from true homologous traits during phylogenetic analysis.

129. (B) It reduces redundancy by collapsing overlapping EST reads into singular representative consensus sequences
Transcriptomic datasets often contain many identical or overlapping fragments from the same gene, which can make analysis difficult. To simplify the data, researchers use a process that groups these similar reads together. By combining the information from multiple fragments into a single consensus sequence, the overall volume of data is reduced while the accuracy and length of the transcripts are improved, facilitating better gene identification and functional studies.

130. (A) 2, 1, 4, 3
Computer-aided drug discovery follows a specific sequence of computational tasks to identify new inhibitors. The process begins with obtaining the structure of the target protein. Next, large collections of chemical compounds are virtually screened to find potential matches. These candidates are then docked into the target's active site and scored based on their binding energy. Finally, the most promising molecules are further optimized to improve their potency and safety.

131. (A) Knowledge of at least one, and preferably several, known active small molecules against the target
When the three-dimensional structure of a target protein is unknown, researchers can still search for new drugs by focusing on the properties of known inhibitors. This approach requires having a dataset of molecules that are already known to be active against the target. By analyzing the shared features of these molecules, researchers can build a model to screen for new compounds that are likely to have similar biological effects.

132. (C) Increase in entropy due to the release of ordered water molecules (desolvation)
The interaction between a drug molecule and its target is governed by the laws of thermodynamics. In an aqueous environment, water molecules form ordered layers around hydrophobic surfaces. When a hydrophobic ligand binds to a hydrophobic pocket, these water molecules are released, increasing the disorder of the system. This gain in entropy provides a powerful driving force for binding, making it a critical factor in determining affinity and potency.

133. (A) Lipophilicity
A molecule's ability to cross fatty biological membranes is a key factor in determining its effectiveness as a drug. This property is quantified by a numerical value that measures how a compound distributes between an organic solvent and water. This parameter reflects the overall hydrophobicity of the molecule, which influences how it moves through the body and interacts with its target, making it a central descriptor in quantitative modeling of drug activity.

134. (D) All molecules in the dataset must be structurally superimposed based on a common pharmacophore or scaffold
Comparative field analysis requires that all molecules in the study are positioned in a consistent way. Because the interaction energies are calculated at specific points in a three-dimensional grid, the spatial orientation of each ligand is critical. Researchers must align the molecules so that their shared chemical features occupy the same space. This superimposition ensures that the resulting statistical model accurately reflects the structural requirements for biological activity.

135. (A) I, III and V
Machine learning involves several distinct types of algorithms that learn from data in different ways. Some methods use complex mathematical functions to map data into higher dimensions for better classification, while others are inspired by biological neural systems and

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transforms raw data into a highly reliable and well-documented resource that serves as a gold standard for protein research and functional genomics.

120. (B) 3, 2, 1
Sequence alignment algorithms have evolved from rigorous mathematical approaches to fast heuristic methods. The earliest techniques focused on global similarity across the entire sequence length. Later, algorithms were developed to identify only the best matching local segments, which is more biologically relevant for many studies. Finally, highly optimized heuristic programs were created to search massive databases rapidly, allowing researchers to find similar sequences in seconds rather than hours.

121. (D) Much smaller than the Gap Opening Penalty
Alignment algorithms use specific penalties to account for the presence of gaps in sequences. Biologically, starting a new gap is a less common event than making an existing gap longer. To reflect this, the cost associated with continuing a gap is set to a much lower value than the cost of initiating it. This affine gap model encourages the algorithm to produce fewer, longer gaps, resulting in more biologically plausible alignments.

122. (A) The matrix is derived from blocks of sequences sharing up to 62% identity
Substitution matrices used for protein comparison are often identified by a specific numerical value. This number represents the clustering threshold used when building the matrix from conserved sequence blocks. For example, a value of sixty-two means that the matrix was derived from sequences that are no more than sixty-two percent identical. This allows the matrix to be optimized for detecting similarities at different levels of evolutionary divergence.

123. (B) Visualizing large-scale genomic rearrangements, such as inversions and duplications
Dot plots are an effective way to visually compare two sequences and identify structural differences. By placing one sequence on each axis and marking identical residues with a dot, specific patterns emerge that highlight large-scale changes. Diagonal lines indicate regions of similarity, while breaks and shifts in these lines reveal the presence of insertions, deletions, inversions, and duplications, providing a rapid overview of genomic evolution and rearrangements.

124. (B) Breaking the alignment problem into smaller, overlapping sub-problems and building the optimal solution in a tabular format
Finding the mathematically best alignment between two sequences requires a systematic approach that considers every possible combination. A specific computational strategy achieves this by dividing the large problem into a grid of smaller, manageable steps. The algorithm calculates the best score for each cell based on previous results, building a complete table of information. This ensures that the final result is the absolute best possible alignment under the given scoring parameters.

125. (D) IV only
Rapid database searching tools provide statistical measures to help researchers evaluate their findings. The significance of a match is measured by the expectation value, which tracks how many random matches are expected. Another measure provides a score that is independent of the database size. While these tools are highly efficient for finding similar regions, they are fundamentally local search programs rather than global alignment algorithms that force an end-to-end comparison.

126. (C) Constructing the guide tree
Progressive multiple sequence alignment follows a structured series of steps to organize sequences efficiently. After calculating the pairwise distances between all sequences, the algorithm uses this information to build a branching structure. This tree determines the order in which sequences will be added to the final alignment, starting with the most similar pairs and gradually incorporating more distant ones. This approach balances computational speed with accurate representation of evolutionary relationships.

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127. (D) The total number of evolutionary changes (substitutions) across the entire tree
Phylogenetic reconstruction often relies on a simplicity principle to find the best tree. This approach evaluates different tree structures and counts the total number of character changes required to explain the observed sequences. The topology that requires the absolute fewest mutations is selected as the most likely

78. (C) Gap Opening, Gap Extension, Length of the gap
Scoring sequence alignments with gaps requires a model that distinguishes between starting a new gap and making an existing one longer. The total penalty is calculated by adding a fixed cost for the initial break to the product of the length and a smaller extension cost. This affine model ensures that long gaps are penalized less severely than multiple short ones, reflecting biological reality.

79. (D) Stringency/Windowing threshold
Dot matrix plots can often become cluttered with random noise, making it difficult to see true regions of similarity. To improve clarity, researchers apply a filtering technique that requires a minimum number of matches within a specific segment length. This stringency requirement ensures that only significant clusters of matches are displayed, highlighting the most relevant biological similarities while removing background noise from the plot.

80. (A) 2, 3, 4, 1
Building a quantitative model for drug activity involves a structured workflow. The process begins with collecting high-quality experimental data on how a series of compounds affect a biological target. Next, numerical descriptors are calculated for each molecule's structure. These values are then used to build a statistical model, which must be rigorously validated to ensure it can accurately predict the activity of new compounds.

81. (B) The cumulative gap penalty for alignments with empty sequences
Dynamic programming for global alignment requires the initialization of the scoring matrix boundaries. The first row and column represent the cost of aligning the initial residues of one sequence with a series of gaps in the other. These values are calculated by progressively adding the gap penalty for each step, establishing the starting conditions for the algorithm to fill the rest of the matrix.

82. (D) FASTA
Traditional dynamic programming is mathematically thorough but too slow for searching large databases. Heuristic methods achieve high speed by first looking for short, exact matches called words or k-tuples. These matches serve as seeds that are later extended to form full alignments. This approach significantly reduces the computational time required to find similarities, making it practical for routine large-scale genomic searches.

83. (A) It translates both nucleotide sequences into all six reading frames, requiring 36 distinct pairwise comparisons
Searching for similarity between two DNA sequences at the protein level can be computationally intensive. One advanced tool translates both the query and every sequence in the database into all six possible reading frames. Because this requires a large number of pairwise comparisons for every match, it is much slower than simpler nucleotide searches but offers much higher sensitivity for detecting distant relationships.

84. (C) Iterative methods refine initial alignments through repeated realignment passes, correcting early errors
Multiple sequence alignment accuracy can be limited by the "once a gap, always a gap" rule of progressive methods. To overcome this, some algorithms use a strategy that repeatedly realigns subgroups of sequences. This iterative process allows the algorithm to optimize the overall score and correct misaligned gaps, leading to a more accurate representation of homology.

85. (A) I, II and IV
Phylogenetic analysis involves various methods and assumptions. Distance-based approaches compute numerical differences between sequences, while some methods specifically assume that all lineages evolve at the same rate. To assess the reliability of the resulting tree, researchers use statistical techniques that resample the data to see how often specific groups appear. Understanding these core principles is essential for interpreting evolutionary trees and their branch support.

86. (D) Bootstrapping
Determining the statistical confidence of a phylogenetic tree is a critical step in evolutionary analysis. Researchers use a resampling technique that creates many pseudo-datasets by randomly picking columns from the original alignment. A tree is built for each new dataset, and the percentage of times a specific group of organisms appears together is recorded. This value provides

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require a training phase to adjust their internal parameters. Additionally, some techniques focus on identifying natural groupings in the data without using predefined labels, providing valuable insights into molecular similarity and diversity.

136. (C) UniProtKB
A comprehensive resource for protein information combines high-quality manual annotation with extensive sequence coverage. This database provides detailed records for protein function, subcellular location, and post-translational modifications, all supported by literature and experimental evidence. By integrating data from multiple sources and maintaining a non-redundant collection of sequences, it serves as the primary authoritative repository for protein research and functional genomics worldwide, facilitating advanced biological discovery and analysis.

137. (D) mmCIF (macromolecular Crystallographic Information File)
As biological structures become larger and more complex, traditional file formats have reached their limits. A newer, more flexible system was developed to store detailed information for massive macromolecular assemblies. This format uses a hierarchical structure that allows for much larger datasets and more extensive metadata, ensuring that all aspects of the experiment and the resulting model are accurately recorded. It has become the standard for archiving structural data in modern biology.

138. (A) EB-eye (EBI Search)
Efficiently searching the vast amount of biological data at major European research centers requires a powerful and fast search engine. A specific system was designed to provide rapid access to information stored across hundreds of different databases. By indexing sequences, structures, and literature in a unified way, this tool allows researchers to perform broad queries and quickly find the most relevant information, serving as a critical resource for the global scientific community.

139. (B) Exact matches of characters in aligned positions
Quantifying the similarity between two biological sequences often starts with a simple measure of identical residues. This score is calculated by identifying the number of positions where both sequences share the exact same character in an alignment. While this provided a clear and direct measurement of similarity, it is important to remember that it does not account for conservative substitutions that may still preserve the protein's overall function and structure.

140. (A) Both A and R are true and R is the correct explanation of A.
Evolutionary models used for sequence alignment use specific matrices to score similarities based on the probability of mutations. One particular matrix is optimized for comparing sequences that have diverged significantly over a long period. It represents a model where a large number of point mutations have occurred per hundred residues. This allows the algorithm to detect distant relationships that would be missed by matrices designed for more closely related sequences.

141. (A) Terminating the traceback when a zero is reached, avoiding negative cumulative scores
Local alignment algorithms are specialized for finding matching regions between sequences that are not similar overall. The key mathematical difference from global methods is how the scoring matrix is calculated and searched. By preventing the cumulative score from becoming negative and ending the alignment when the score drops to zero, the algorithm can isolate and identify only the most significant local regions of similarity, providing a more focused and biologically relevant analysis.

142. (C) Expectation value (E-value) cutoff
Managing the quality of results in large-scale database searches requires statistical thresholds. Researchers use a specific parameter to filter out matches that are likely to have occurred by random chance. By setting a strict limit on this value, the search tool only reports alignments that are statistically significant. This ensures that the results are likely to be biologically meaningful and share an evolutionary relationship, rather than being coincidental matches of residues.

143. (D) T-Coffee
Accuracy in multiple sequence alignment can be enhanced by integrating different types of alignment information. One advanced tool uses a consistency-based approach that combines results from both local and global pairwise alignments. This information is stored in a library and used

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189. (A) Pose generation (search algorithm) and binding affinity evaluation (scoring function)
Simulating how a small molecule binds to a protein target involves two primary computational challenges. First, the algorithm must explore the many different ways the molecule can fit into the active site, a process called search. Second, it must have a way to estimate the strength of the interaction for each of these possible orientations, using a mathematical formula known as a scoring function. Together, these tasks allow researchers to predict the most likely binding mode and potency of potential drug candidates.

190. (A) Both A and R are true and R is the correct explanation of A.
Quantitative models that analyze molecular fields are extremely sensitive to the spatial arrangement of the molecules in the dataset. Because interaction energies are calculated at fixed points on a three-dimensional grid, the ligands must be perfectly aligned with each other. If the molecules are not superimposed correctly, the calculated steric and electrostatic fields will not correspond to the same structural features, leading to a model that is biologically meaningless and unable to accurately predict activity.

191. (D) Solvent accessible surface area (SASA)
Molecular descriptors are numerical values used to characterize different physical and chemical properties of compounds. Some descriptors require knowing only the connectivity of atoms, while others are derived from the precise three-dimensional shape of the molecule. One important geometric parameter measures how much of the molecule's surface is available to interact with the surrounding solvent. This value is critical for understanding solubility and how a drug candidate might interact with its target, requiring detailed atomic coordinates for accurate calculation.

192. (C) Support Vector Machines (SVM)
Classifying chemical compounds based on their biological activity often requires finding complex boundaries in data. One powerful machine learning technique achieves this by mapping molecular descriptors into a high-dimensional space. In this space, the algorithm identifies a specific boundary that maximizes the distance between different classes of molecules, such as active and inactive compounds. This robust approach is highly effective for handling complex biological datasets and providing accurate predictions for new drug candidates in pharmaceutical and agricultural research.

193. (B) mRNA
The flow of genetic information from the permanent DNA storage to the protein-making machinery requires a temporary carrier. This messenger molecule is synthesized from the DNA template and carries the instructions for building a specific protein to the ribosomes. This intermediate step is a fundamental part of the central dogma, allowing the cell to control gene expression and produce the necessary proteins for life while keeping the original genetic information safe within the nucleus of the cell.

194. (D) Pfam
Organizing the vast diversity of proteins into functional groups requires sophisticated models that capture the essential features of each family. One major secondary database uses probabilistic models based on multiple sequence alignments to define protein domains and families. These models are particularly good at detecting distant relationships and identifying the functional parts of a sequence. This resource is essential for functional genomics, providing a comprehensive and reliable classification system for proteins across all domains of life.

195. (A) It incorporates both coding and non-coding experimentally derived nucleotide sequences
A primary international repository for genetic information archives a wide range of DNA and RNA sequences submitted by researchers worldwide. This database is not limited to genes that code for proteins; it also includes non-coding regions, regulatory elements, and structural RNAs. By storing all experimentally derived nucleotide data, it provides a comprehensive resource for studying genome structure, evolution, and function, serving as a critical foundation for all areas of biological research, from basic science to applied biotechnology.

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196. (C) >
Standardizing how sequence data is shared is essential for modern bioinformatics. One of the most common formats uses a very simple structure that is easy for computers to read. Each sequence record begins with a specific symbol on a single line, followed immediately by

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superimposition, causing singularities near atomic centers
Traditional field-based QSAR models often face numerical problems when probe atoms get too close to the molecule, leading to extreme energy values. This makes the models very sensitive to even tiny changes in how the molecules are aligned. A newer methodology solves this by using a smooth function to calculate interaction fields. This approach avoids the problematic singularities and produces more stable models that are less dependent on the exact details of molecular superimposition.

152. (C) To introduce non-linearity into the model, allowing it to solve complex patterns
Artificial neural networks process data through layers of nodes that are interconnected. Each node uses a specific mathematical function to transform its input before passing it to the next layer. This step is critical because it allows the model to capture complex, non-linear relationships between molecular structure and biological activity that simple linear methods might miss. This flexibility makes neural networks very powerful tools for modeling the complex behavior of drug molecules in biological systems.

153. (D) Accession number
Every sequence record in major biological databases is assigned a unique identifier that remains constant over time. This string of characters allows researchers to easily track and cite specific sequences across different studies and platforms. Unlike other identifiers that might change if the record is updated, this stable name ensures that the data can be reliably retrieved and referenced, providing a critical foundation for data management and collaboration in the scientific community.

154. (A) EBI (European Bioinformatics Institute)
A major international center for biological data management is located in Europe and maintains several critical repositories. One of its primary roles is to host and curate a large collection of nucleotide sequences as part of a global collaboration. This organization provides a wide range of tools and resources for researchers, ensuring that biological information is organized, accessible, and well-documented for the worldwide scientific community, supporting diverse research areas from medicine to agriculture.

155. (B) RefSeq
Genomic research requires high-quality, non-redundant reference data to ensure accurate analysis. A specific resource provides expertly curated sequences for genomes, transcripts, and proteins that serve as a standard for the scientific community. These records are built using a combination of automated and manual processes to ensure consistency and reliability. By providing a stable and well-annotated set of sequences, this resource facilitates comparative studies, gene mapping, and the interpretation of high-throughput sequencing data.

156. (B) Entrez Neighbor/Link computations
Interconnected databases at the National Center for Biotechnology Information use a powerful system to help users find related information. By calculating the similarity between different records, the system creates links that allow researchers to jump directly from a sequence to its corresponding structure, literature, or genomic location. This automated cross-referencing significantly enhances data discovery, making it easy to explore the complex biological context of any gene or protein through a single integrated interface.

157. (A) Inference of homology
When two biological sequences show a high level of similarity, researchers often conclude that they share a common evolutionary ancestor. This logical step is based on the idea that such a high degree of matching is unlikely to occur by random chance. While similarity is a measurement of shared characters, homology is a hypothesis about their evolutionary history. This inference is the foundation for transferring functional and structural information between related genes and proteins.

158. (C) The gap opening penalty is generally smaller than the gap extension penalty
Alignment algorithms use specific costs to manage the introduction of gaps, which represent evolutionary insertions or deletions. Biologically, starting a new gap is much less likely than extending one that has already occurred. Therefore, the penalty for starting a gap is set much higher than the penalty for making it longer. Understanding this relationship is critical for choosing the right parameters to produce alignments that accurately reflect the true evolutionary history of the sequences.

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204. (B) Position-specific gap penalties utilizing structural masks
The accuracy of a multiple sequence alignment can be improved by incorporating information about the protein's three-dimensional shape. Some parts of a protein, like alpha-helices, are very important for stability and are less likely to contain insertions or deletions. Advanced alignment tools use specific settings to increase the cost of putting gaps in these regions. By protecting the core structural elements, the resulting alignment is more likely to be biologically correct and reflect the physical constraints that govern protein evolution and function.

205. (A) It illustrates relationships among taxa without specifying the evolutionary path or direction
Evolutionary relationships can be represented by different types of trees. One specific type shows how organisms are related to each other but does not identify a specific common ancestor for the entire group. Because it lacks a root, this tree does not provide a direction for time or clarify which character states are ancestral. It is useful for representing overall similarity and divergence when a suitable outgroup or reference point is not available to determine the evolutionary origin of the group.

206. (C) Maximum Likelihood
Advanced phylogenetic methods use statistical models to find the tree that best explains the observed sequence data. This approach calculates the probability of seeing the specific alignment for many different possible tree topologies, using a model that describes how nucleotides change over time. The tree that results in the highest probability is selected as the best estimate of evolutionary history. This method is highly respected for its statistical rigor and ability to account for complex evolutionary processes.

207. (D) Hisat2 / STAR (Splice-aware aligners)
Analyzing the messenger RNA content of a cell requires mapping millions of short sequence reads back to a reference genome. This is challenging because the transcripts are processed to remove non-coding regions, meaning a single read might match two distant locations on the genome. Specialized software has been developed to handle these "spliced" alignments, allowing for the accurate mapping of transcripts and the identification of active genes and their alternative versions in high-throughput sequencing studies.

208. (C) Constructing novel ligand molecules entirely from scratch within the spatial constraints of the target receptor pocket
When researchers have a detailed map of a protein's active site, they can design new drugs by building them one piece at a time directly within that space. This approach, known as starting from scratch, involves placing small chemical fragments into the pocket and linking them together to create a molecule that perfectly fits the target's shape and chemical environment. This method allows for the discovery of entirely new types of molecules that have never been synthesized before, potentially leading to more potent drugs.

209. (B) Free Energy Perturbation (FEP)
Accurate prediction of binding affinity is a major goal in drug discovery but is extremely difficult due to the complex physics involved. One highly sophisticated method uses intensive computer simulations and quantum mechanics to calculate the change in free energy as a molecule binds to its target. While this approach is very accurate, it requires massive amounts of processing power, making it too slow for initial screening but valuable for the final stages of optimizing a drug candidate's potency.

210. (D) Wiener Index
Molecular structure can be represented by numerical values that reflect different aspects of a compound's shape and connectivity. One classic descriptor is calculated from the molecular graph by summing the distances between all pairs of carbon atoms. This value provides a measure of the branching and overall size of the molecule, which are important factors in determining its physical properties and biological activity. This topological index was one of the first developed and remains a useful tool in chemical modeling.

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211. (A) q^2
Evaluating the internal reliability of a quantitative model for biological activity requires statistical validation. One important metric is calculated by repeatedly leaving out a single data point and using the rest of the data to predict its value. The correlation between these predicted values and the actual observed data provides a measure of how robust the model is. A high value for

are met, the resulting tree provides a highly reliable and logically sound representation of the evolutionary history of the group.

167. (B) SAGE (Serial Analysis of Gene Expression)
Measuring gene expression on a large scale often involves counting short, unique sequences that represent individual transcripts. This technique involves linking these small tags together into long chains, which are then sequenced. By counting how often each tag appears, researchers can quantify the expression levels of thousands of genes simultaneously. This provides a powerful way to study how different tissues or conditions affect the functional output of the genome without needing pre-existing gene models.

168. (C) It provides extensive open-source modules for sequence parsing, alignment tools, and database interactions
Many bioinformaticians prefer a specific programming environment because of the vast amount of ready-to-use tools available. These libraries provide specialized functions for handling DNA and protein sequences, running alignment programs, and accessing major international databases. Because the code is open-source, it is constantly being improved and expanded by the scientific community. This rich ecosystem of tools makes it easy to develop complex analysis pipelines and encourages the sharing of code and methods across different research labs.

169. (D) The 3D geometry and physicochemical properties of the receptor's binding site determine the binding affinity of the ligand
Modern drug design is based on a detailed understanding of the physical interactions between molecules. It assumes that the potency of a drug candidate is determined by how well it fits into the target protein's active site. The shape of the pocket and the distribution of charges and other chemical features within it dictate which molecules will bind strongly. By modeling these three-dimensional characteristics, researchers can design new inhibitors that are tailor-made to fit the target with high precision.

170. (A) Genetic Algorithms
Searching for the best way a drug molecule fits into a protein requires exploring a vast number of possible shapes and positions. One sophisticated search strategy uses principles inspired by biology to find the optimal solution. It starts with a population of random poses and uses mechanisms like selection and mutation to evolve better-fitting versions over many generations. This approach is highly effective at finding the global energy minimum in complex landscapes, leading to more accurate binding predictions.

171. (B) The steric bulk of a substituent relative to a methyl group
Quantitative modeling of chemical activity involves using descriptors that represent different molecular features. One specific parameter was developed to measure the physical size of chemical groups attached to a molecule. By comparing the rate of a reaction with a specific substituent to the rate with a standard methyl group, researchers can quantify how the bulkiness of the group affects the process. This value is critical for understanding steric effects in drug-target interactions and optimizing molecule size.

172. (B) Cross-validated q^2 or external $R^2_{\{pred\}}$
Ensuring that a mathematical model for drug activity is truly predictive requires rigorous testing. While a model may fit the initial training data well, it must be evaluated on its ability to predict the activity of new, unseen compounds. Researchers use statistical measures that involve setting aside a portion of the data during the training process to see how well the model performs on these independent samples. High values for these metrics provide confidence in the model's reliability for drug design.

173. (A) SVR easily models highly non-linear relationships by utilizing kernel functions to map data into high-dimensional feature spaces
Modeling biological activity is often difficult because the relationships between structure and function are not always simple and linear. One advanced machine learning technique addresses this by transforming the data into a more complex space where it is easier to find patterns. This allows the model to capture non-linear effects that would be missed by traditional methods. This flexibility makes it a powerful tool for building highly accurate and robust predictive models in pharmaceutical and agricultural research.

174. (C) Synthesizing a polypeptide chain from an mRNA template at the ribosome
The flow of genetic information in a cell culminates in the production of functional proteins. This

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159. (D) BLOSUM matrix
Substitution matrices are essential for scoring protein alignments based on the probability of residues changing. One widely used series is built by analyzing highly conserved regions within large protein families. These matrices are derived from observed frequencies of amino acid changes in local alignments, without assuming a specific evolutionary model. This empirical approach makes them highly effective for database searches and for identifying distant homologs that share essential functional or structural motifs.

160. (A) 2, 3, 4, 1
Creating a multiple sequence alignment using the progressive strategy involves a logical sequence of computational tasks. The process begins with pairwise comparisons to measure how similar each sequence is to every other sequence. This information is used to build a distance matrix, which then guides the construction of a tree. Finally, the sequences are added to the alignment one by one, following the branching order of the tree to ensure the most similar ones are aligned first.

161. (B) In the bottom-right cell representing the end of both sequences
Global alignment algorithms use dynamic programming to find the best possible match across the entire length of two sequences. The algorithm systematically fills a scoring matrix, building up the total alignment score as it considers every possible match, mismatch, and gap. The final result, representing the highest overall score for the complete sequences, is found in the very last cell calculated, which corresponds to the final residues of both sequences being compared.

162. (D) K-tuples or words
Speed is a critical factor when searching for similarity in large biological databases. Heuristic methods achieve high performance by focusing on short, identical segments of a fixed length. These small units, often called words, are used to quickly identify promising regions for full alignment. By first finding these exact matches, the algorithm can skip large portions of the database that are unlikely to contain significant similarities, significantly reducing the computational time required for the search.

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163. (A) tblastx
Some sequence comparison tasks are much more computationally expensive than others. One advanced search program translates both the query and every sequence in the database into all six possible reading frames. This results in thirty-six distinct pairwise protein comparisons for every match, requiring massive amounts of processing power. While slow, this approach is extremely powerful for identifying distant evolutionary relationships between DNA sequences that are invisible to simpler nucleotide-based comparison tools.

164. (C) By increasing gap penalties within hydrophobic core regions (which rarely tolerate insertions/deletions) and decreasing them in hydrophilic surface loop regions
The accuracy of multiple sequence alignments can be improved by considering the structural properties of proteins. Some regions, like the tightly packed interior, are very intolerant to changes, while flexible loops on the surface can easily accommodate insertions or deletions. Advanced alignment tools use this information to adjust gap penalties at different positions. By making it harder to put gaps in the core and easier in the loops, the resulting alignment more accurately reflects the physical reality of the protein.

165. (A) Phylogram
Evolutionary trees can be drawn in several ways to highlight different aspects of the data. One specific type of tree uses the length of the branches to represent the amount of evolutionary change that has occurred. In these diagrams, the distances between nodes are proportional to the number of substitutions that have accumulated along each lineage. This provides a clear visual representation of both the relationships between organisms and the relative amount of divergence they have experienced.

166. (D) When sequences are closely related and the amount of homoplasy is low
Choosing the best phylogenetic method depends on the nature of the sequences being analyzed. One popular approach is based on the principle of simplicity, seeking the tree that requires the fewest evolutionary changes. This method is most effective when the sequences are quite similar and there are few instances of traits evolving independently. When these conditions

homologs that share important biological roles but have overall divergent sequences.

182. (D) By restricting scores from falling below zero, placing a 0 in the cell instead of a negative number
Local alignment algorithms are specialized for finding matching regions between sequences that are otherwise different. The mathematical trick that allows this is preventing the cumulative score in the dynamic programming matrix from becoming negative. By setting any negative result to zero, the algorithm can start a new alignment at any point, effectively resetting the process when the similarity between sequences drops below a biologically meaningful level, ensuring that only significant local matches are identified.

183. (B) The scoring matrix, gap penalties, sequence length, and the total size of the searchable database
The statistical significance of a sequence match in a database search is determined by several factors. The expectation value depends not only on the raw alignment score but also on the specific parameters used, such as the scoring matrix and gap costs. Additionally, the size of the search space, defined by the lengths of the query and the entire database, influences how likely a match is to occur by random chance. Correctly interpreting this value is essential for identifying true biological relationships.

184. (C) Errors in early alignment stages that cannot be corrected
Progressive multiple sequence alignment is a popular and fast method, but it has a fundamental weakness known as the "local minimum" problem. Because the alignment is built step-by-step following a guide tree, the most similar sequences are aligned first. If any mistakes are made during these initial steps, such as placing a gap in the wrong position, those errors become permanent and will influence all subsequent steps as more sequences are added to the alignment.

185. (D) Leaf/Terminal node
Phylogenetic trees are composed of several parts that represent evolutionary relationships. The tips of the branches represent the individual organisms or sequences that were actually sampled and analyzed. These terminal points signify the extant taxa, while the internal points and branches represent the hypothetical ancestors and the paths of evolutionary change. Correctly identifying these elements is essential for interpreting the branching patterns and understanding the current diversity of life in the context of its shared evolutionary history.

186. (A) Maximum Parsimony
Phylogenetic reconstruction often uses a principle from philosophy to choose between different possible trees. This approach favors the simplest explanation, which in this case is the tree that requires the absolute minimum number of evolutionary changes to explain the observed sequence data. By minimizing the total count of mutations, this method provides a logically sound way to estimate evolutionary history, particularly when analyzing closely related sequences where the amount of independent evolution is low.

187. (B) A short (200-800 bp), unedited sequence read from either the 5' or 3' end of a cDNA clone
Studying the expressed genes of an organism often involves creating libraries of complementary DNA from messenger RNA. Researchers then sequence the ends of these clones to generate short, unedited reads that act as unique identifiers for each transcript. These tags are invaluable for gene discovery and mapping, providing a snapshot of the active genes in a specific cell type or condition. They are archived in specialized databases that support transcriptomic research and functional genomics across many different species.

188. (B) Commercial software source code is hidden, whereas open-source code is transparent
The biological software landscape is divided between two different development models with distinct legal and practical implications. One model involves proprietary products where the underlying instructions are kept secret by the company. The other model relies on transparency, making the full source code available for anyone to inspect, modify, and improve. This openness is particularly important in research, as it allows for independent verification of methods and fosters collaboration by allowing scientists to build upon each other's work freely.

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final step involves reading the information carried by a messenger molecule and using it to assemble a specific sequence of amino acids. This complex process occurs at specialized cellular structures and is guided by transfer molecules that decode the genetic message. Understanding this mechanism is essential for studying how genes control the growth, development, and resilience of organisms like agricultural crops.

175. (B) II, III and IV
Bioinformatics involves several specialized databases that characterize protein sequences and families in different ways. Some use patterns and regular expressions, while others rely on probabilistic models to identify conserved domains. These different resources are often integrated into larger, unified platforms to provide a comprehensive view of protein function and evolution. Knowing how these databases work and the types of models they use is essential for accurate sequence analysis and functional annotation in modern biological research.

176. (C) INSDC
The global repository of nucleotide sequence data is managed through a formal partnership between three major international organizations. These centers, located in the United States, Europe, and Japan, collaborate to ensure that all genetic information submitted to any of them is shared and synchronized daily. This global cooperation ensures that researchers everywhere have access to a consistent and comprehensive database of genetic information, supporting scientific discovery and international collaboration in all fields of biology.

177. (B) X-ray crystallography and Nuclear Magnetic Resonance (NMR) spectroscopy
Determining the precise three-dimensional structure of biological macromolecules is a major challenge in structural biology. Two primary experimental techniques provide the majority of the coordinates archived in global structural databases. One method involves analyzing the diffraction patterns of crystallized molecules, while the other uses the magnetic properties of atomic nuclei in solution to determine their spatial relationships. These methods provide the atomic-level detail necessary for understanding protein function and designing new drug candidates with high specificity.

178. (D) It restricts the search to records that contain both queried terms, narrowing the results
Searching for specific biological information requires using logical operators to refine and focus the results. When combining multiple search terms, a specific operator ensures that the system only returns records where all the terms are present. This is particularly useful for narrowing down a search to a specific organism and a particular biological process, helping researchers filter out irrelevant data and find the most pertinent sequences or literature for their studies in a highly efficient manner.

179. (A) Xenologs - Origin via horizontal gene transfer
Homologous genes are classified based on the evolutionary events that led to their divergence. While many genes are inherited vertically from parent to offspring, some are transferred between unrelated species through different mechanisms. These genes, which have a horizontal origin, are identified by a specific term that distinguishes them from those resulting from speciation or gene duplication. Recognizing these different types of homology is essential for accurately reconstructing evolutionary histories and understanding the diversity of life.

180. (C) 1%
Substitution matrices used for sequence alignment are based on specific evolutionary models. In one common series, each unit represent a specific amount of change. The base matrix in this series is calculated by observing mutations in very closely related proteins, where only a tiny fraction of the amino acids have undergone substitution. This provides an empirical foundation for scoring alignments, which can then be extrapolated to create matrices for comparing more distantly related sequences over evolutionary time.

181. (A) BLOSUM is derived from conserved protein blocks, avoiding mathematical extrapolation errors
Choosing the right scoring matrix is essential for detecting distant evolutionary relationships. One widely used matrix series is built directly from local alignments of conserved protein segments, rather than being extrapolated from a model of closely related sequences. This empirical approach captures the actual frequencies of amino acid changes in functional domains, making these matrices particularly effective for identifying conserved motifs and finding distant

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a description or identifier for that sequence. The actual DNA or protein sequence then follows on the subsequent lines. This simple and flexible arrangement has become the universal language for exchanging sequence information between different software programs.

197. (A) PDBx/mmCIF
As structural biology progresses, scientists are solving the structures of increasingly large macromolecular complexes, such as ribosomes. Traditional file formats for storing atomic coordinates had a hard limit on the number of atoms and chains they could hold, making them unsuitable for these massive assemblies. A newer, more flexible system was developed that uses a hierarchical dictionary structure to handle datasets of any size. This format has become the new standard, ensuring that even the most complex biological structures can be accurately archived.

198. (D) Using the [AU] or [Author] search field tag
Finding all the scientific papers published by a specific researcher requires a targeted search strategy. Major citation databases allow users to use specific labels to restrict their query to particular fields. By attaching a specific tag to a person's name, the search engine will only return records where that name appears in the author list. This helps researchers quickly and accurately retrieve the complete publication history of an individual, filtering out irrelevant results that might share the same name elsewhere.

199. (B) High primary sequence homology heavily implies shared structural topology and biological function
A fundamental principle of bioinformatics is that the properties of a protein can be predicted from its sequence similarity to others. This assumes that if two proteins share a high degree of identical and similar amino acids, they are likely to fold into a similar three-dimensional shape and perform a similar biological function. This inference allows researchers to transfer knowledge from well-studied proteins to newly discovered ones, providing a powerful way to annotate genomes and understand the functional diversity of life.

200. (A) P-4, Q-3, R-1, S-2
Sequence comparison tools offer several specialized programs for different research needs. Some compare proteins directly, while others compare DNA sequences. Certain programs add sensitivity by translating nucleotide sequences into protein sequences in all possible reading frames before searching. Other tools perform the opposite, comparing a protein query against a DNA database that has been translated. Choosing the right combination of query and database is essential for finding the most relevant similarities and understanding the evolutionary relationships between sequences.

201. (D) At the bottom-right cell representing the end of both sequences
Global alignment algorithms use a two-step process to find the best match between two sequences. After filling a scoring matrix with values that represent the best score at each position, the algorithm must work backward to reconstruct the actual alignment. This process starts at the very last cell of the matrix, which corresponds to the final residues of both sequences. By following the path of maximum scores back to the beginning, the algorithm identifies the optimal global alignment across their entire lengths.

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202. (A) FASTA
Searching massive genomic databases requires algorithms that are much faster than traditional dynamic programming. One highly efficient method achieves high speed by first looking for short, exact matches of a fixed length. By building a dictionary of these matches and using specialized data structures, the program can rapidly identify regions that are likely to contain significant similarities. This heuristic approach allows researchers to perform routine database searches in seconds, making it a critical tool for modern genomic research and annotation.

203. (B) The gap propagates inflexibly throughout the entire final alignment
Progressive multiple sequence alignment is a step-by-step process that builds an alignment following the branching order of a tree. This method is fast but has a significant drawback: once a gap is introduced in an early step, it cannot be moved or removed later. If the first pair of sequences is misaligned, that error will be carried through all subsequent steps, potentially leading to an incorrect final alignment that does not reflect the true evolutionary history of the sequences.

to guide the final multiple alignment, ensuring that the result is consistent with all the available pairwise data. This method is particularly effective for difficult-to-align sequences with complex evolutionary histories.

144. (C) Rooted tree
A phylogenetic tree that includes a specific starting point provides a clear direction for evolution. This origin represents the common ancestor from which all other organisms in the tree have descended. By identifying this node, the tree allows researchers to track the temporal sequence of branching events and determine which character states are ancestral. This rooted structure is essential for accurately interpreting the evolutionary history and relationships within a group of organisms.

145. (A) P-3, Q-4, R-1, S-2
Phylogenetic reconstruction involves several distinct methodologies based on different principles. Some methods use distance matrices to cluster sequences, assuming either equal or variable evolutionary rates. Other approaches analyze the alignment directly, seeking either the tree that requires the fewest mutations or the one that makes the data most probable under a statistical model. Understanding these fundamental differences is essential for choosing the most appropriate method for a given evolutionary study.

146. (D) Vector and adapter trimming
Raw sequence data from transcripts often contain technical artifacts that must be removed before biological analysis. During the cloning and sequencing process, pieces of foreign DNA from vectors and adapters are often attached to the sequence of interest. If these are not removed, they can interfere with assembly and lead to incorrect functional annotations. Specialized software is used to identify and strip these sequences, ensuring that only the target genetic information remains.

147. (A) Commercial software restricts source code modification and redistribution via proprietary licenses
The biological software ecosystem includes both proprietary and open-source tools, each with different legal requirements. Commercial products are protected by licenses that prevent users from seeing or changing the underlying code and restrict how the software can be shared. In contrast, open-source licenses ensure that the source code remains transparent and available for everyone to modify and redistribute, fostering a collaborative research environment and ensuring the long-term accessibility of scientific tools.

148. (C) Ligand-based drug design (e.g., pharmacophore modeling using known active compounds)
When researchers face a new biological target with no known structure or similar proteins, they must rely on the properties of active molecules to guide drug discovery. By analyzing a set of compounds that are already known to bind to the target, they can identify the essential geometric and chemical features required for activity. This model is then used to screen for new drug candidates that share these critical features, allowing for discovery even without structural data.

149. (A) Force-field-based scoring functions
Estimating the binding affinity of a drug candidate requires a way to calculate the energy of the protein-ligand complex. One common approach uses mathematical functions that simulate physical forces at the atomic level. These functions account for attractions and repulsions between atoms, including electrostatic and van der Waals interactions. By summing these physical contributions, the algorithm can predict how strongly a molecule will bind to its target, providing a foundation for virtual screening.

150. (A) P-3, Q-4, R-2, S-1
Quantitative modeling of drug activity involves a specific set of variables and relationships. The property being predicted, such as potency, is the dependent variable, while the numerical descriptions of the molecular structure are the independent variables or descriptors. The mathematical equation that connects these two is the regression model. Correctly identifying these components is essential for building and interpreting models that can accurately predict the biological performance of new chemical compounds.

151. (B) The high sensitivity of CoMFA's Lennard-Jones potentials to slight changes in molecular

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this metric suggests that the model is stable and likely to perform well on new, unseen compounds.

212. (C) They can model complex, non-linear relationships between molecular descriptors and toxicity
Artificial neural networks are powerful machine learning tools that are particularly well-suited for modeling complex biological systems. Unlike traditional methods that assume simple linear relationships, these models can identify and capture intricate, non-linear patterns in the data. This flexibility makes them highly effective for predicting the potential toxicity and activity of new agrochemicals, where many different factors interact in complex ways to determine the overall biological effect of a compound on a target organism.

213. (A) Protein to Protein or Protein to Nucleic Acid
The flow of genetic information in living systems follows specific rules that were first outlined decades ago. While information can be copied from DNA to RNA and even from RNA back to DNA, the rules state that once information has been converted into a protein, it cannot be passed back to a nucleic acid or transferred between proteins. This unidirectionality is a core principle of biology, ensuring that the genetic blueprint remains the ultimate source of information for the cell.

214. (D) PDBsum
Navigating the vast amount of structural information available for macromolecules is made easier by resources that provide pre-calculated summaries. One specific database collects data from multiple sources to provide a clear overview of every structure in the international repository. It includes detailed drawings of the protein's domain architecture, domain topology, and binding sites, as well as information about any ligands present. This integrated resource is invaluable for researchers who need to quickly understand the functional and structural context of a specific protein.

215. (A) I and II
Global coordination is essential for managing the massive amounts of genetic information produced by researchers worldwide. A formal partnership between three major international organizations ensures that all nucleotide sequence data is shared and synchronized daily. This cooperation ensures that GenBank, the European Molecular Biology Laboratory, and the DNA Data Bank of Japan all contain the same up-to-date information. This open-access system provides a comprehensive and consistent resource for the entire scientific community, supporting research and discovery across all fields of biology.

216. (C) "drought"[All Fields] AND "Triticum aestivum"[Organism] AND biomol_genomic[PROP]
Finding specific biological information in a massive database requires building a precise query using logical operators and labels. To find genomic sequences related to drought tolerance in wheat, a researcher would combine the specific condition, the scientific name of the organism, and a label for genomic DNA. By using the logical AND operator, the search engine will only return records that meet all these criteria, effectively filtering out thousands of irrelevant results and providing a focused set of data for analysis.

217. (D) Similarity accounts for substitutions that preserve biochemical properties and 3D folding
When comparing proteins, it is important to distinguish between exact matches and changes that do not affect function. A simple measure of identity only counts identical residues, but many amino acids have similar physical and chemical properties. A measure of similarity accounts for these conservative changes, recognizing that a substitution between two similar residues is more likely to preserve the protein's structure and activity over evolutionary time. This makes similarity a more biologically meaningful measure of relationship than identity alone.

218. (A) BLOSUM45 is derived from highly conserved blocks with only 45% sequence identity, capturing deep evolutionary divergence
Choosing the right scoring matrix is critical for finding distant evolutionary relationships. One series of matrices is built from conserved blocks of protein sequences, with different matrices optimized for different levels of similarity. A matrix with a lower number, like forty-five, was derived from sequences that share less identity. This makes it more sensitive for detecting distantly related proteins that have undergone significant changes, while matrices with higher numbers are better for comparing sequences that are still very similar to each other.

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234. (A) Gap opening penalty
Sequence alignment algorithms use specific parameters to account for mutational events such as insertions and deletions. When the algorithm must introduce a break in a sequence to maximize matches elsewhere, it applies a specific cost known as a gap opening penalty. This parameter prevents the excessive introduction of gaps, ensuring that the resulting alignment reflects biologically plausible evolutionary relationships rather than coincidental matches between unrelated residues that do not share a common evolutionary history.

235. (C) III only
Substitution matrices used for protein comparison are identified by numbers that represent the identity threshold used during their construction. These matrices are optimized for different levels of evolutionary divergence. A matrix with a higher number was built using more similar sequences, making it better for comparing closely related proteins. Conversely, matrices with lower numbers are more sensitive for detecting distantly related proteins that have undergone significant changes, providing a versatile tool for general-purpose sequence analysis and database searching.

236. (B) Requiring M matches within a sliding window of length W
Dot plots are powerful visual tools for comparing sequences, but they can often be cluttered with random noise from coincidental matches. To improve the clarity of the plot, researchers apply a filtering rule that requires a minimum number of matches within a specific segment length. This stringency requirement ensures that only significant clusters of matches are displayed as lines on the plot, highlighting true regions of biological similarity while removing the background noise that can obscure important features.

237. (A) Its dynamic programming nature makes it computationally prohibitive for massive databases
While dynamic programming provides the mathematically best local alignment between two sequences, it is extremely slow for searching massive genomic databases. The time required to fill the entire scoring matrix grows quickly with the size of the sequences and the database. Because of this high computational cost, researchers typically use faster heuristic methods for routine database searches, reserving rigorous dynamic programming for detailed analysis of specific sequences once potential matches have already been identified.

238. (C) k-tuple (word size)
Rapid database searching relies on initial short matches to identify potential regions of similarity. The length of these matches, known as the word size, is a critical parameter that determines the speed and sensitivity of the search. By first finding these short, exact matches, the algorithm can quickly focus on the most promising parts of the database. This heuristic approach significantly reduces the time required for the search, making it practical to scan millions of sequences in a reasonable timeframe.

239. (D) PSI-BLAST
Finding distant evolutionary relationships between proteins often requires more sensitivity than a single database search can provide. One advanced tool achieves this by performing multiple rounds of searching. After the first round, it builds a specific scoring model based on the most significant matches and uses this model for the next search. This iterative process allows the program to detect subtle patterns that are characteristic of a protein family, revealing distant homologs that share essential functional motifs.

240. (A) Both A and R are true and R is the correct explanation of A.
Accuracy in multiple sequence alignment can be limited by the step-by-step nature of progressive methods, where early mistakes are permanent. To overcome this, some algorithms use a strategy that repeatedly realigns subsets of the sequences to refine the overall score. This iterative process allows the system to escape from local optima and correct errors made in the early stages, resulting in a more accurate and biologically plausible final alignment that better reflects the evolutionary history of the sequences.

241. (B) Cladistics
Evolutionary relationships between organisms can be classified based on different principles. One approach focuses on identifying groups that share newly evolved traits that were not present in their ancestors. These shared derived characters are used to define clades, which include

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new software that is created by modifying the original code must also be released under the same open-source terms. This policy prevents the privatization of community-developed software and fosters a collaborative and transparent research environment.

227. (A) The spatial ensemble of steric and electronic features necessary to ensure optimal interactions with a biological target
In drug design, a pharmacophore represents the core set of features required for a molecule to interact with a specific biological target. It is not a single physical structure but a geometric map of essential characteristics, such as hydrophobic regions and electrostatic charges, in three-dimensional space. This model is used to search large chemical libraries for new compounds that possess these critical features, allowing for the discovery of potential drug candidates with high binding affinity and specificity.

228. (C) Incremental Construction by placing a core fragment and adding flexible side chains
Simulating how a flexible drug molecule binds to a protein can be done by building the molecule one piece at a time within the active site. This approach starts by placing a rigid central part of the molecule and then progressively adding the remaining flexible segments. Each piece is positioned to maximize favorable interactions with the receptor. This step-by-step construction allows the algorithm to explore many different shapes and orientations, leading to a more accurate prediction of the binding mode.

229. (A) Partial Least Squares (PLS) Regression
Quantitative modeling of drug activity often involves analyzing a large number of descriptors that are highly correlated with each other. This collinearity can make traditional regression models unstable. An advanced statistical technique solves this problem by transforming the original data into a smaller set of independent components. These components are designed to capture the maximum amount of information that relates the molecular structure to the observed biological activity, resulting in more robust and predictive models for drug discovery.

230. (A) 4, 2, 1, 3
Preparing a protein structure for docking follows a series of logical steps to ensure the model is physically realistic. The process begins with obtaining the atomic coordinates from a global structural repository. Next, water molecules and other solvents used in the experiment are removed, and hydrogen atoms are added to the structure. Finally, partial charges are calculated for each atom to accurately represent the molecule's electrostatic properties. This preparation is essential for accurate binding energy calculations.

231. (B) Support Vector Machines (SVM) maximizing the margin between the active/inactive classes
Classifying compounds based on their biological activity often requires finding the best possible boundary between different groups in a dataset. One powerful machine learning technique achieves this by mapping molecular descriptors into a high-dimensional space. In this space, the algorithm identifies a specific boundary, known as a hyperplane, that maximizes the distance between the different classes of molecules. This robust approach provides a powerful and accurate way to predict the activity of new drug candidates.

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232. (C) GenBank
A major international center in the United States maintains a primary repository for all experimentally determined nucleotide sequences. This database is part of a global collaboration that ensures genetic information is shared and synchronized daily with other major centers in Europe and Japan. This open-access resource provides a comprehensive and up-to-date collection of genetic information, supporting biological research and discovery across all fields, from medicine to agriculture, for scientists worldwide.

233. (D) A definition line beginning with '>' followed by sequence characters
Sharing sequence data between different bioinformatics programs requires standardized file formats. One of the most widely used and simple formats consists of a single header line that starts with a specific symbol, followed by a description of the sequence. The actual DNA or protein sequence is then provided on the lines below. This simple structure is easy for both humans and computers to read, making it a universal standard for exchanging genetic and protein information in modern biological research.

features. One specific database collects data from multiple primary sources to provide a clear overview of every structure in the global repository. It includes detailed information about the protein's domain architecture, domain topology, and binding sites. This integrated resource is invaluable for researchers who need to quickly understand the functional and structural context of a specific protein through a single interface.

279. (B) The percentage identity threshold used to group sequences in the blocks database (e.g., 62% in BLOSUM62)
Substitution matrices used for protein alignment are identified by specific numbers that represent how they were built. These matrices are derived from conserved sequence blocks, with the number representing the threshold used to cluster sequences together. For example, a value of sixty-two means the matrix was built using sequences that are no more than sixty-two percent identical. This allows the matrix to be optimized for detecting similarity at different levels of evolutionary divergence, providing a versatile tool for analysis.

280. (A) 2, 3, 4, 1
Mathematically optimal sequence alignment using dynamic programming follows a structured series of computational steps. The process begins by defining the scoring parameters, including match rewards and gap costs. Next, the boundaries of the scoring matrix are initialized, and the rest of the matrix is filled with maximum possible scores for every position. Finally, a traceback procedure is used to reconstruct the best alignment by following the path of optimal scores from the end back to the beginning.

281. (D) The mathematically optimal alignment across the entire lengths of both sequences
Global alignment algorithms are designed to find the best possible match across the entire length of two sequences. By systematically evaluating every possible combination of matches, mismatches, and gaps using dynamic programming, the algorithm ensures that the final result represents the mathematically highest score for the complete sequences. This approach is essential for comparing sequences that are overall very similar and share an evolutionary relationship across their entire lengths, providing a comprehensive view of their similarity.

282. (A) The expected number of distinct alignments with a score equivalent to or better than the observed score that could occur strictly by chance
The statistical significance of a sequence match in a database search is measured by the expectation value. This parameter estimates how many random alignments with a similar score would be expected to occur by chance in a database of a given size. A very low value indicates that the match is likely to be biologically meaningful and share a common evolutionary ancestor, rather than being a coincidental match between unrelated sequences in the massive search space.

283. (B) Sequence Retrieval System (SRS)
Efficiently searching multiple biological databases requires a unified interface that can handle diverse data formats. One major retrieval system became a standard in Europe for its ability to index flat-file records from many different sources. This allowed users to perform complex cross-database queries and easily navigate between sequences, structures, and functional annotations. This integrated approach significantly streamlined the data retrieval process, making it a critical tool for researchers working with large and diverse biological datasets.

284. (B) Jukes-Cantor distance
Estimating evolutionary distances between sequences requires accounting for the fact that a single site can undergo multiple substitutions over time. Simple measures of difference will underestimate the true amount of change. One common mathematical correction uses a specific model of sequence evolution to estimate the actual number of substitutions that have occurred. By correcting for hidden mutations, this method provides a more accurate measure of evolutionary distance, which is essential for reconstructing reliable phylogenetic trees and timelines.

285. (A) 3' Poly-A tail
Studying the functional parts of the genome requires focusing on the sequences that are expressed as messenger RNA. In eukaryotic cells, these transcripts undergo specific modifications, including the addition of a long string of adenine nucleotides at one end. This unique feature allows researchers to easily isolate the transcripts from other types of cellular RNA. Once purified, these molecules are used to create complementary

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a common ancestor and all of its descendants. This method provides a clear and logically sound way to reconstruct the branching patterns of life and accurately reflect the true evolutionary history and relationships within a group.

242. (D) General Time Reversible (GTR)
Accurate phylogenetic modeling requires complex models of sequence evolution that account for the different ways nucleotides change over time. The most sophisticated models allow for different rates between all possible types of substitutions and recognize that the four bases do not occur with equal frequency. By including these details, the model provides a more realistic representation of the evolutionary process, leading to more accurate estimates of tree topologies and branch lengths in molecular phylogeny studies.

243. (A) A contig (contiguous sequence)
Analyzing transcript data involves combining millions of short sequence fragments that represent different parts of the same gene. When these overlapping reads are aligned and combined, they form a single, continuous consensus sequence. This assembled sequence represents a much larger portion of the original transcript, providing a clearer picture of the gene's structure and function. These assemblies are essential for gene discovery, mapping transcripts to the genome, and identifying the functional products of an organism's genetic code.

244. (C) Software source code is proprietary, highly maintained, and licensed for a fee, providing standardized interfaces and support
The biological software market includes products developed and sold by companies for a fee. These proprietary tools are protected by licenses that restrict access to the underlying source code and limit how the software can be shared. In exchange, the companies provide professional maintenance, regular updates, and dedicated customer support. This model offers standardized and reliable tools for researchers who need stable and well-supported interfaces for their complex biological data analysis and drug discovery projects.

245. (B) Ligand-based design - Requires known active ligands
When the structure of a target protein is unknown, researchers can still search for new drugs by focusing on the properties of molecules that are already known to bind to it. This approach requires having a dataset of active compounds to serve as a starting point. By analyzing these molecules, researchers can identify the essential features required for activity and use this information to screen for new drug candidates, even without a three-dimensional map of the receptor's active site.

246. (D) The geometric and conformational exploration of the ligand fitting into the receptor's active site
Simulating the binding of a small molecule to a protein involves a detailed exploration of physical space. The algorithm must consider many different ways the molecule can be positioned, rotated, and folded within the target's active site. This process aims to identify the specific orientation and shape that allows for the most favorable interactions with the receptor. By systematically searching through these possibilities, the algorithm can predict how the two molecules will fit together to form a stable complex.

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247. (B) Randic topological index
Molecular descriptors are numerical values that represent specific features of a compound's structure. Some descriptors focus on the connectivity of atoms and the overall branching of the molecular framework. One specific index is calculated by analyzing the bonds in a hydrogen-suppressed molecular graph, providing a measure of how the atoms are connected and the general size and shape of the molecule. This topological descriptor is widely used in quantitative modeling to understand how structural features influence biological activity.

248. (C) Utilizing a distance-dependent Gaussian function in CoMSIA to avoid field singularities
Traditional field-based QSAR models often face mathematical problems where interaction energies become infinite when atoms overlap. This makes the models extremely sensitive to small changes in molecular alignment. An improved methodology addresses this by using a smooth function to calculate interaction fields. This approach eliminates the problematic singularities and produces more stable models that are less dependent on the exact details of molecular superimposition, providing a more

219. (B) A direct repeat
Visualizing sequence patterns through a self-comparison dot plot allows for the rapid identification of repeated elements. When a segment of DNA or protein occurs more than once in the same orientation, it produces diagonal lines that are parallel to the main identity diagonal but offset from it. These lines clearly mark the position and length of the repeats, providing a simple way to identify duplications and other structural features that are important for understanding genome evolution and protein function.

220. (B) Needleman-Wunsch
Local alignment algorithms are specialized for finding the best matching regions between two sequences, even if they are overall very different. Unlike global methods that look at the entire sequence, these algorithms focus on identifying the highest-scoring local segment. The best local alignment is found by searching the entire scoring matrix for the maximum value, which marks the end of the highest-scoring region. This approach is essential for identifying conserved domains and functional motifs that are shared between divergent proteins.

221. (A) Extreme Value Distribution (Gumbel distribution)
Determining the significance of a sequence match in a database search requires a specific statistical model. The distribution of scores from random alignments does not follow a normal bell curve; instead, it is skewed toward higher values. A specific mathematical function is used to model this behavior, providing the foundation for calculating expectation values. This statistical rigor ensures that researchers can differentiate between true biological relationships and coincidental matches that occur by chance in large-scale database searches.

222. (C) It utilizes an unchanging substitution matrix for all sequences regardless of evolutionary distance
A popular multiple sequence alignment tool uses several advanced features to improve accuracy. It starts by building a guide tree from pairwise distances and then aligns the sequences following the tree's branches. Critically, it does not use the same scoring parameters for every step. Instead, it adjusts the substitution matrix based on how similar the sequences are, using different matrices for closely related and distant pairs. This adaptive approach ensures that the scoring is optimized for every level of evolutionary divergence.

223. (D) The presence of a single node representing the most recent common ancestor of all entities in the tree
Establishing the direction of evolutionary time requires a specific type of tree structure. By identifying a single starting point, the tree represents the common ancestor from which all other lineages have diverged. This rooted structure allows researchers to determine the relative order of branching events and distinguish between ancestral and newly derived character states. Identifying this root is essential for accurately reconstructing evolutionary history and understanding the true relationships between different organisms or sequences.

224. (C) UPGMA
Certain phylogenetic methods rely on the assumption that mutations accumulate at a constant rate across all lineages. This molecular clock hypothesis simplifies the calculation of evolutionary time and results in a tree where all the tips are the same distance from the root. While this approach is simple and mathematically elegant, it is often considered restrictive because evolutionary rates can vary significantly between different species and lineages over time.

225. (B) Computationally stripping out vector, adapter, primer, and low-quality sequences
Raw sequence data from transcripts must be thoroughly cleaned before it can be used for biological analysis. During the laboratory process, foreign DNA from the vectors and adapters used for cloning is often attached to the sequence of interest. If these technical artifacts are not removed, they can interfere with the assembly of the transcripts and lead to errors. Specialized software is used to identify and remove these sequences, ensuring that only the target genetic information remains for research.

226. (D) GNU General Public License (GPL)
The biological software community often uses a specific type of license to ensure that tools remain freely available. This license, often called copyleft, guarantees that anyone can access the source code, modify it, and share it. However, it also includes a critical requirement: any

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databases into a single searchable interface. By combining information from multiple sources, this tool provides a more comprehensive and reliable classification of protein families and functional sites. This integrated approach is essential for large-scale genomic studies, as it allows researchers to rapidly and accurately annotate the functional potential of newly discovered sequences.

257. (B) T-Coffee
Accuracy in multiple sequence alignment can be improved by integrating information from different sources. One advanced tool uses a consistency-based approach that combines results from both local and global pairwise alignments. This information is stored in a library and used to guide the final multiple alignment, ensuring that the result is consistent with all the available pairwise data. This method is particularly effective for difficult-to-align sequences, as it leverages the strengths of multiple alignment methods to produce a more reliable final result.

258. (D) It iteratively selects pairs of taxa that minimize the total length of the branches in the tree, producing an unrooted tree
Constructing phylogenetic trees for large numbers of sequences requires efficient algorithms that do not evaluate every possible tree shape. One popular distance-based method builds the tree by sequentially joining the most similar pairs of taxa. At each step, it chooses the pair that results in the shortest overall branch length for the entire tree. This approach is computationally very fast and produces an unrooted tree that accurately reflects the evolutionary distances between the sequences in the dataset.

259. (A) ML utilizes an explicit mathematical model of sequence evolution to calculate the probability of the data, while MP simply minimizes the number of evolutionary changes
Phylogenetic reconstruction methods differ in how they evaluate the best tree topology. One approach is based on a simplicity principle, seeking the tree that requires the fewest evolutionary changes. Another approach uses an explicit statistical model of how sequences change over time to calculate the probability of observing the data for a given tree. While both methods analyze character data directly, they use different logical foundations to estimate the most likely evolutionary history of a group of organisms.

260. (A) 2, 3, 1, 4
Designing drugs without a known receptor structure follows a structured ligand-based workflow. The process begins by collecting a set of diverse molecules that are already known to be active. These compounds are then carefully aligned to identify their common chemical and geometric features. From this superimposition, a geometric model, or pharmacophore, is built to represent the essential interaction requirements. Finally, this model is used to virtually screen chemical libraries for new compounds that match the required pattern.

261. (A) CrossMatch / Vector NTI
Raw sequence data from transcripts must be thoroughly cleaned of technical artifacts before it can be used for biological research. During the sequencing process, pieces of DNA from the vectors used for cloning are often attached to the sequence of interest. If these are not removed, they can interfere with assembly and functional annotation. Specialized software compares the raw reads against known vector sequences to identify and strip away the foreign DNA, ensuring that only the target transcript information remains.

262. (D) Internal conformational strain (torsional entropy)
The binding of a drug molecule to its target involves not only the interactions between the two molecules but also the energy required for the drug to adopt its binding shape. If the molecule must twist into an energetically unfavorable conformation to fit into the active site, this will reduce its overall binding affinity. Scoring functions in molecular docking simulations account for this by applying a penalty for such internal strain, ensuring more accurate predictions of potency and binding mode.

263. (B) Partial Least Squares (PLS)
Quantitative modeling of biological activity often involves many molecular descriptors that are highly correlated with each other. This collinearity can make traditional regression models unstable and unreliable. An advanced statistical technique addresses this by transforming the original data into a smaller set of independent components. These components are designed to maximize the

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relationship between the molecular structure and the observed biological activity, resulting in more robust and predictive models for drug discovery and molecular design.

264. (C) Total molecular weight (sum of atomic masses)
Molecular descriptors are numerical values that represent different aspects of a chemical compound's structure. Some descriptors are very simple and do not require any information about how the atoms are connected or their three-dimensional shape. One classic example is the total mass of the molecule, calculated by summing the weights of all its atoms. While simple, these basic descriptors provide important information about the overall size and properties of a compound, serving as a foundation for quantitative modeling.

265. (D) SVM strictly ignores all descriptor values
Machine learning classification in bioinformatics involves identifying the best way to separate different groups in a dataset. One powerful technique achieves this by mapping molecular descriptors into a high-dimensional space where it can find an optimal boundary between classes. This boundary maximizes the margin between the groups, such as active and inactive compounds. By considering all the provided descriptor information, the algorithm can make accurate and robust predictions for new sequences or drug candidates based on complex structural patterns.

266. (A) GenBank
A major international center in the United States maintains a primary repository for all experimentally determined nucleotide sequences. This database is part of a global collaboration that ensures genetic information is shared and synchronized daily with other major centers in Europe and Japan. This open-access resource provides a comprehensive and up-to-date collection of genetic information, supporting biological research and discovery across all fields, from medicine to agriculture, for scientists worldwide through a single, authoritative platform.

267. (B) Acting as a centralized directory consolidating nomenclature, map, sequence, expression, and functional data for individual genes
A centralized resource at the National Center for Biotechnology Information provides a comprehensive overview of every known gene. This directory integrates information from many different sources, including nomenclature, genomic location, sequence data, and functional annotations. By consolidating this diverse information into a single searchable record, the system makes it easy for researchers to explore the full biological context of any gene, facilitating gene discovery and the study of genetic function across many different species.

268. (B) Orthologs
Homologous genes that are found in different species and originated from a single gene in a common ancestor are identified by a specific term. These genes are separated when their original lineage splits through speciation. Because they typically maintain the same biological function over time, they are the primary focus of comparative genomic studies and are essential for understanding evolutionary relationships and the functional conservation of genetic information across the diversity of life on Earth.

269. (A) An affine gap penalty
Alignment algorithms use specific cost models to account for the presence of gaps in sequences. Biologically, starting a new gap is a less likely event than extending one that has already occurred. An affine penalty model reflects this by applying a higher cost for the initial break and a smaller cost for each additional position in the gap. This approach encourages the algorithm to produce fewer, longer gaps, resulting in more biologically plausible and accurate alignments of evolutionary sequences.

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270. (A) Both A and R are true and R is the correct explanation of A.
Multiple sequence alignment accuracy can be improved by considering the structural constraints that govern protein evolution. Some regions, like the flexible loops on the surface, are much more tolerant to changes than the tightly packed interior. Advanced alignment tools use this information to adjust gap penalties. By making it easier to put gaps in the surface loops and harder in the core structural elements, the

resulting alignment more accurately reflects the physical reality of the protein.

271. (D) Polytomy
Evolutionary relationships are represented by branching diagrams where nodes indicate common ancestors. In some cases, the data may not be sufficient to determine the exact order of divergence, leading to a node where more than two lineages split simultaneously. This unresolved branching pattern indicates a period of rapid evolution or a lack of information. Correctly identifying these points is important for understanding the limits of our knowledge about the evolutionary history and relationships within a specific group.

272. (C) Purine to Purine or Pyrimidine to Pyrimidine
Molecular evolution models distinguish between different types of nucleotide changes based on the chemical structure of the bases involved. One common type of mutation involves substituting a base with another of a similar chemical class, such as one purine for another. These changes are much more frequent than those between different classes. Accurate phylogenetic reconstruction requires accounting for these different rates, leading to more realistic models of sequence evolution and more reliable estimates of evolutionary relationships.

273. (B) Short, single-pass reads of cDNA libraries
Studying the expressed parts of the genome involves creating libraries of complementary DNA from messenger RNA. A specialized division of the national nucleotide database was created to archive short, single-pass sequence reads from these clones. These tags provide a snapshot of the active genes in a specific cell type or condition and are invaluable for gene discovery and mapping. This resource supports transcriptomic research across many different species, providing a critical foundation for functional genomics studies.

274. (D) It strictly assumes both the ligand and the target receptor are completely inflexible, ignoring induced-fit phenomena
Rigid-body molecular docking assumes that both the ligand and receptor remain completely rigid during binding. This simplifies computations but ignores induced-fit conformational changes that often occur when a ligand binds to its target. Consequently, rigid docking may produce less accurate binding predictions for flexible molecules, making flexible docking methods more suitable for realistic protein–ligand interaction studies.

275. (A) I and II
Machine learning involves several different types of models with distinct architectures. One approach builds an ensemble of many decision trees to make predictions, while another uses interconnected layers of nodes that are trained to recognize complex patterns. These sophisticated methods are particularly effective for modeling biological data, as they can capture non-linear relationships and identify the most important features for predicting activity or function. Understanding these different architectures is essential for choosing the right machine learning tool for biological research.

276. (C) The Lennard-Jones interaction potential between a standard probe atom (e.g., sp^3 Carbon) and the superimposed ligand
Quantitative modeling of drug activity often involves analyzing the physical shape and interaction potential of molecules in three-dimensional space. By placing molecules on a grid, researchers can calculate the energy between the molecule and a probe atom at every grid point. This steric field represents the volume occupied by the molecule and its potential for physical interactions. These values are used in statistical models to identify which parts of the molecule are most important for its biological potency.

277. (A) RNA replication via RNA-dependent RNA polymerase
The classical central dogma describes a one-way flow of information from DNA to RNA and then to proteins. However, the life cycle of certain viruses shows that this is not the only path. Some viruses can copy their genetic information directly from one RNA molecule to another without using a DNA template. This discovery expanded our understanding of biological information transfer and provided new insights into viral replication and the diversity of genetic mechanisms in the natural world.

278. (D) PDBsum
Navigating structural information for macromolecules is made easier by resources that provide pre-calculated summaries of structural

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reliable way to model the relationship between structure and activity.

249. (D) Random Forests
Machine learning models can be used to identify which molecular descriptors are most important for predicting biological activity. One ensemble method builds many decision trees and measures how much the accuracy of the model drops when a specific descriptor's values are randomly shuffled. This assessment provides a clear ranking of feature importance, helping researchers understand which structural properties have the greatest influence on potency and guiding the design of more effective drug candidates in pharmaceutical research.

250. (A) P-3, Q-1, R-4, S-2
Bioinformatics involves a wide range of specialized software tools for different analysis tasks. Some programs are designed for aligning multiple sequences, while others simulate how molecules bind to each other. Additionally, some tools focus on constructing evolutionary trees or performing rapid similarity searches in large databases. Knowing the primary function of each tool is essential for navigating the complex landscape of biological data analysis and choosing the most appropriate method for every research project.

251. (B) Prion-mediated protein-to-protein conformational transfer
The classical central dogma describes a one-way flow of genetic information from nucleic acids to proteins. However, certain biological phenomena challenge this simple view. One such example involves infectious proteins that can transmit their misfolded shape to other proteins of the same type. This process represents a flow of information directly between proteins, bypassing the nucleic acid templates entirely. This discovery expanded our understanding of biological information transfer and provided new insights into complex diseases and inheritance.

252. (B) It exclusively houses structures generated purely via computational ab initio predictions
A global structural repository serves as the primary center for archiving the three-dimensional coordinates of macromolecules. Importantly, this database only includes structures that have been determined using experimental methods like X-ray crystallography or NMR spectroscopy. It does not include models that were created purely through computer predictions. This ensures that the data in the repository is based on physical evidence, providing a reliable foundation for structural biology research, drug design, and molecular modeling worldwide.

253. (A) E-value
Statistical evaluation is critical for determining whether a sequence match in a database search is biologically significant. Researchers use a specific parameter that measures the expected number of random matches with a similar score. A very low value indicates that the alignment is unlikely to have occurred by chance, suggesting a true evolutionary relationship. This measure accounts for the size of the search space and the specific scoring parameters, providing a robust way to identify meaningful biological similarities.

254. (C) 1 accepted point mutation per 100 amino acids
Substitution matrices used in sequence alignment are built on models that track evolutionary change over time. In one common matrix series, the base unit represents a specific amount of mutation where a tiny percentage of the residues have changed. This provides an empirical measure of evolutionary distance, which can then be extrapolated to create matrices for comparing sequences that have diverged significantly over long periods. This systematic approach allows for the statistical evaluation of similarity between divergent proteins.

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255. (A) I and II
Organizing the vast space of protein structures requires hierarchical systems based on different classification philosophies. Some resources rely on manual review to group proteins by their evolutionary connections, while others use semi-automated methods to classify proteins based on their shape and secondary structure arrangements. These systems provide different but complementary ways to explore the structural and functional relationships between proteins, helping researchers understand the diverse ways that proteins fold and interact in living systems.

256. (C) InterPro
Characterizing protein function and evolution often requires searching for multiple types of signatures, such as motifs and domains. A composite resource integrates several specialized

DNA libraries, providing the raw material for sequencing and gene expression studies.

286. (C) It averages or combines the scores from multiple distinct scoring functions to reduce false positives and improve predictive accuracy
Predicting binding affinity in molecular docking is a major challenge due to the limits of individual scoring functions. One advanced strategy addresses this by combining the results from several different functions. By looking for candidates that score well across multiple models, researchers can reduce the number of false positives and improve the overall accuracy of their predictions. This consensus approach provides a more robust and reliable way to identify the most promising drug candidates during virtual screening.

287. (D) Partition coefficient (LogP)
A molecule's ability to cross fatty biological membranes is a critical factor in determining its effectiveness as a drug. This property is quantified by a numerical value that measures how a compound distributes between an organic solvent and water. This parameter reflects the overall hydrophobicity of the molecule, which influences how it moves through the body and interacts with its target. It is a central descriptor in quantitative modeling, providing essential information for predicting the physical and biological behavior of drugs.

288. (C) Comparative Molecular Similarity Indices Analysis (CoMSIA)
Quantitative modeling of drug activity often involves analyzing molecular fields calculated at specific points in space. One advanced methodology improves upon earlier techniques by using a smooth Gaussian function to calculate interaction fields, avoiding mathematical problems at atomic centers. This approach is highly effective for characterizing the steric, electrostatic, and hydrophobic features of ligands. By using statistical techniques like partial least squares, it builds robust models that relate these three-dimensional features to the biological activity of chemical compounds.

289. (B) PLS - Unsupervised clustering algorithm requiring no biological activity data
Statistical modeling in drug discovery involves several different types of algorithms for analyzing molecular data. One advanced regression technique is specifically designed to handle many correlated descriptors by transforming them into independent components that maximize the relationship with biological activity. Because this method requires active participation of the dependent variable to build its model, it is classified as a supervised learning approach. Understanding these differences is essential for choosing the right statistical tool for predictive modeling and structural analysis.

290. (A) Both A and R are true and R is the correct explanation of A.
When comparing proteins that have diverged significantly over evolutionary time, their three-dimensional shape is often much better preserved than their primary amino acid sequence. Because the structural fold is essential for biological function, it is under strong evolutionary pressure to remain stable even as mutations accumulate in the sequence. Therefore, aligning structures provides a much more reliable way to identify distant evolutionary relationships and functional similarities between proteins than sequence comparison alone could achieve.

291. (A) SWISS-PROT
The quality of protein sequence data is ensured through a rigorous review process. While many entries are initially generated by automated systems, a subset of the data undergoes extensive manual checking. Experts review the available literature and experimental evidence to provide high-quality functional annotations. This process transforms raw data into a highly reliable and well-documented resource that serves as the gold standard for protein research. By maintaining a non-redundant collection of sequences, it provides a consistent foundation for genomics.

292. (C) A probabilistic model of sequence conservation at each position in an alignment, factoring in match, mismatch, and gap probabilities
Characterizing protein families requires models that can capture the essential patterns of sequence conservation. One advanced approach uses a probabilistic model derived from a multiple sequence alignment to represent each position. This model accounts for the likelihood of different amino acids appearing at each site, as well as the probability of insertions or deletions. These profiles are highly effective for detecting distant relationships and identifying functional

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domains in new sequences, providing a powerful tool for genome annotation.

293. (A) Neighbor-Joining
Phylogenetic reconstruction methods are classified based on the type of data they use to build the tree. Some methods analyze the alignment directly, while others first reduce the sequences to a numerical measure of similarity. One popular algorithm uses a distance matrix to sequentially group the most similar pairs of taxa. By minimizing the overall branch length at each step, it produces a reliable tree very quickly, making it suitable for large-scale evolutionary studies across many species.

294. (D) The number of evolutionary changes or substitutions per site that have occurred along that branch
Evolutionary relationships are represented by branching diagrams where the length of the branches can convey different types of information. In one specific type of tree, the branch lengths are proportional to the amount of molecular change that has accumulated along each lineage. These distances represent the estimated number of substitutions per site, providing a clear visual representation of how much each organism has diverged from its common ancestors. This quantitative view is essential for interpreting evolutionary history.

295. (B) Molecular docking
Simulating how a small molecule binds to a protein target involves exploring its geometric orientation, position, and physical shape within the active site. The goal is to identify the specific configuration that allows for the most favorable physical and chemical interactions with the receptor. By systematically searching through many possible poses and evaluating them with a scoring function, the algorithm can predict how the two molecules will fit together to form a stable and functional complex.

296. (C) A mathematical regression fit to an experimental dataset of known ligand-receptor binding energies
Estimating the binding affinity of a drug candidate requires mathematical functions that can rapidly calculate interaction energy. One common approach uses parameters that have been calibrated using a large dataset of known protein-ligand complexes with experimentally measured binding constants. By fitting these parameters to match the observed data, the function can provide a reliable estimate of potency for new compounds based on their physical features in the binding site, supporting high-throughput virtual screening in drug discovery.

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297. (D) To extract latent variables that capture variance in both the 3D fields and the activity
Quantitative modeling of drug activity often involves many correlated molecular descriptors. This collinearity can make traditional regression methods unstable and unreliable. An advanced statistical technique addresses this problem by transforming the original descriptors into a smaller set of independent components. These components are designed to capture the maximum information that relates the three-dimensional interaction fields to the observed biological activity. This results in more robust and predictive models for drug discovery and molecular design in pharmaceutical research.

298. (A) Regression
Predictive modeling in bioinformatics involves identifying the relationship between structural descriptors and biological activity. When the activity is measured as a continuous numerical value, such as an inhibition constant, the statistical task is to find a mathematical function that can predict this value for new compounds. This type of modeling is essential for optimizing the potency of drug candidates, as it allows researchers to understand how changes in molecular structure will influence the overall biological performance.

299. (B) Molar refractivity
Quantitative modeling of chemical activity requires descriptors that capture different physical properties of compounds. One important parameter measures the polarizability of a molecule and is directly related to its physical volume. This value serves as a measure of the steric bulk of a molecule, providing information about its size and how it might fit into a protein's binding site. This information is essential for predicting potency and specificity, helping researchers design molecules that are perfectly sized for their targets.

300. (B) EMBOSS
A comprehensive collection of open-source tools for sequence analysis provides a wide range of

applications for biological research. This suite includes programs for sequence alignment, database searching, and motif identification, all designed to handle various biological data formats. Because it can be used through a command-line interface, it is easily integrated into automated pipelines and workflows. This flexibility and range of tools have made it a staple in modern computational research for scientists working with genomic and proteomic data.

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